

Oil & Gas Reserves
SUFFICIENT



INSUFFICIENT

Geo Politics
SUPPLY



TURMOIL

SABOTAGE

CUTBACKS

The Utility Executive's Field Guide to the Future

GEOLOGY, GEO-POLITICS

and GLOBAL WARMING

Key Issues 2000–2010

Global Warming
FOSSIL FUELS



FEEBLE

OPEC



GREENHOUSE GASES

FEARSOME

REGULATIONS

VOLUNTARY SOLUTIONS

An energy industry study by
Deloitte Consulting and Deloitte & Touche

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BACKGROUND

on the field guide

PURPOSE OF THE FIELD GUIDE

The Utility Executive's Field Guide to the Future provides guidance for utility decision-makers and others caught up in the surging changes creating unprecedented uncertainties in today's utility sector. A product of Deloitte Research – the thought leadership arm of Deloitte & Touche LLP and Deloitte Consulting – the *Field Guide* was developed for reference during a new decade that promises to bring years of new volatility.

Virtually every aspect of the utility business is in flux. Regulatory policies, corporate strategies, and share values provide conflicting clues as to how the sector might evolve. Underlying the contradictions are divergent opinions about the industry's dynamics. Yet despite the lack of clarity, utility executives must make decisions about mergers, divestitures, reorganisations, and capital investments – decisions that fundamentally impact their companies' fortunes.

FIELD GUIDE CONTENTS

The *Field Guide* furnishes strategic insights into a set of factors that will be crucial in shaping the utility marketplace during the new decade. It defines the players and topics that will dominate histories of the utility sector between now and 2010. These include the people and forces that will be influential as well as the issues that will create trendlines and turning points. The *Field Guide's* coverage is divided into four parts:

Part 1: Key Drivers 2000-2010: What They Are, How They Rate

Part 2: Key Issues 2000-2010: Liberalisation and Globalisation

Part 3: Key Issues 2000-2010: Geology, Geo-Politics, and Global Warming

Part 4: Key Issues 2000-2010: Economy and Technology

UNDERLYING RESEARCH

The material in the *Field Guide* comes from a year-long global study by Deloitte Research focusing on issues and trends affecting the utility business during the period 2000-2010.

One part of the research was a worldwide survey of people in utilities, commercial and industrial companies, and engineering firms. Commissioned by Deloitte Research and conducted by the Houston market research firm of Welling & Co., the poll involved telephone interviews with 185 respondents in 15 countries. The two charts below show the breakdown of the survey sample by type of company and location. The respondents have been with their current company about 15 years on average, which suggests that their views provide insight into the perceptions of energy business veterans.

CHART 1. BREAKDOWN OF WELLING & CO. SURVEY RESPONDENTS BY COMPANY TYPE

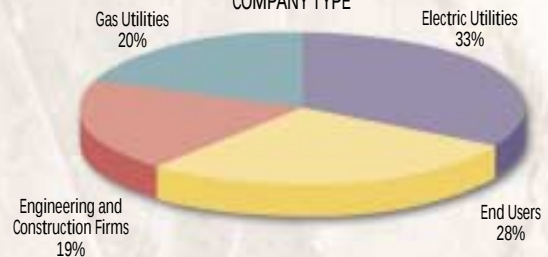
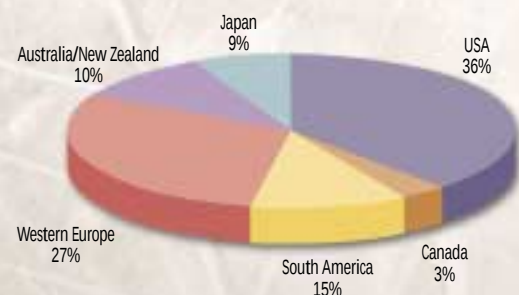


CHART 2. BREAKDOWN OF WELLING & CO. SURVEY RESPONDENTS BY COUNTRY



Another tool was a survey of 600 US households administered for Deloitte Research in 1999 and again in 2000 by International Communications Research (ICR) of Media, Pennsylvania.

To validate and supplement the survey findings, Deloitte Research and the firm's energy practitioners carried out 75 in-depth interviews with utility CEOs, corporate energy managers, government officials, academics, and others in Europe, North America, Australia, New Zealand, and Japan. For other reports and publications based on the Deloitte Research study, consult the Deloitte Research Website at www.dc.com/research.

HIGHLIGHTS

summary

Overview of Differing Expectations for 2000-2010

1. Analysis by Deloitte Research shows the years ahead contain more energy uncertainties than many utilities are taking into account. Between now and 2010, the industry could face the following developments:

- The world's production of conventional oil and gas begins declining, revealing that reserves are less plentiful than previously thought. Alternatively, new discoveries add to proven reserves and send prices plummeting.
- Oil and gas flows suffer chronic interruptions from OPEC holdbacks, turmoil in producing countries, sabotage, and fierce weather. Alternatively, OPEC's cohesion disappears and cartel members flood the market with oil.
- Alarm over global warming leads to taxes and restrictions on the use of fossil fuels in power generation. Alternatively, scientific proof emerges that warming is attributable to natural forces and the case for carbon restrictions vanishes.

2. The extent to which fuels are available and environmentally acceptable affects the strategic options of utilities and other energy companies. At the extremes, chronic supply problems and serious climate concerns could promote government intervention and substitute sources, while prolonged periods of low prices could stunt growth and depress share values. Knowledgeable people inside and outside the energy business assume that over the next 10 years fossil fuel supply and demand will balance and that environmental issues will be manageable.

3. However, our research reveals well-supported contrary views, and the odds of different, less positive scenarios emerging are high enough to merit more attention than they currently receive from many utilities.

4. Accordingly we believe utilities' strategic plans should be designed to cope with multiple contingencies. The fact that experienced and well-qualified people disagree about what the future holds suggests it is unwise to base corporate plans on a single set of assumptions about what is probable.

The more detailed summaries that follow further substantiate our recommendation that utilities should be prepared for multiple possible futures.





Differing Views on the Sufficiency of Oil and Gas

1. Decade of depletion. Some of our findings point to an energy crisis between now and 2010, not because OPEC nations and other producers refuse to pump more oil from their vast reserves, but because reserves prove to be not so vast as previously thought. The pessimists are mainly geologists who contend:

- Estimates of today's conventional oil reserves are grossly inflated.
- The new-discovery rate has been falling for years and will not accelerate.
- New production technologies simply exhaust existing reserves faster.
- Optimistic projections assume production will continue unabated but in reality it starts to taper off once half a field's reserves have been extracted.
- All around the world, oil fields will be reaching their halfway points during the new decade, and the amounts of oil they pump will then decline each year.
- Non-OPEC oil fields are hitting their halfway points first, allowing OPEC's Middle Eastern members to impose new price increases, perhaps as early as 2001.
- Although conventional natural gas production will not peak for another decade or two, gas prices will rise because gas will be used as a substitute for oil, and because it will become clear that, like oil, its days are numbered.
- Obtaining more oil and gas from tar sands, shales, and so on will be more costly than drawing the fuels out of wells and thus the era of cheap energy will become history.

2. Decade of discovery. We also found support for the view that deposits of conventional oil and gas are more than adequate to meet world demand, even with strong economic growth. Proponents of this view, mainly economists, argue that:

- Producers' estimates of plentiful reserves are if anything conservative.
- New technologies make it possible to extract more oil and gas from existing fields than ever before.

■ Technology advances likewise ensure that additional fields will be found.

■ New evidence could confirm an offbeat theory that hydrocarbons originate deep in the earth and collect in deposits all around the world, not just in locations where the oil industry has traditionally looked.

3. Decade of dependence. We also noted an in-between view, which is that overall production will not peak before 2010, but production everywhere except in the Middle East will be falling off. The International Energy Agency lays out this scenario, based on the following assumptions:

- Pessimists are correct that oil production will taper off once half the world's reserves have been removed, but this will not happen before 2010.
- Optimists are correct that technology can promote greater efficiencies and new discoveries, but that will stave off the production decline only until 2013-2014.
- Although total production will not decline before 2010, that is solely because of increased production from the Middle East – all other regions will be on the downside of their production curves, pumping less each year and leaving OPEC's Middle Eastern members increasingly in control of oil prices.

If oil and gas reserves are ample, there will be room for a variety of scenarios depending upon variables such as advances in drilling technology, the state of energy infrastructure, and OPEC's motivations. If reserves are limited, only scenarios involving higher prices will be possible – at least until viable substitutes for fossil fuels mature.

Differing Views on the Reliability of Fuel Production and Delivery

1. Uninterrupted energy flows. Some of those whose views we studied do not expect that producing nations or other factors will hinder energy production and deliveries between now and 2010. They believe that:

- Despite tensions and periodic outbreaks of hostilities, problems in the Middle East during the decade will be manageable.
- In other producing areas such as Russia, the Caspian, and Venezuela, political and economic problems will be contained without affecting energy flows.
- Even if OPEC tries to keep prices up, its efforts will fail because members of the cartel will cheat on their quotas, and high prices will encourage the development of cheaper substitutes.
- Alternatively, Saudi Arabia may flood the market with oil to gain dominance, after which it would be more reasonable to deal with because it would no longer have to placate the more aggressive OPEC members.
- Terrorist sabotage of energy infrastructure will not be a factor because the logistics are so complex, and because of the layers of protection governments have established.

2. Chronic serious stoppages. Others, however, see greater likelihood of interruption. They fear energy flows are increasingly vulnerable, based on the following arguments:

- Religious and ethnic animosities in the Middle East and other key regions will regularly flare into international conflict.
- Middle East and Caspian Basin countries faced with exploding youth populations will be unable to cure shortages of jobs, housing, food, education, and health care, producing a decade of uprisings and coups.
- Outside powers such as Russia, China, India, and Japan will increase their presence in the Middle East and thereby create new rivalries and conflicts.

- Political conflicts in and around the countries of the old Soviet Union will make it difficult to keep fields producing and pipelines operating within Russia and in the Caspian Basin.
- Venezuela, a top foreign oil supplier to the US, will no longer be a reliable source because of antagonism towards the developed world, or because of internal political turbulence.
- Terrorists will be able to avoid detection and launch more effective attacks thanks to the Internet and other new technologies.

The more production and delivery are uninterrupted, the more conditions favour consuming nations and customers, except when supplies are so generous and prices are so low that the energy sector begins to buckle. The more production and delivery are restrained, the more conditions favour the energy sector, except when supplies are so low and prices are so high that customers rebel and new alternatives begin to appear – especially if the reductions are not intentional on the part of producers.

Differing Views on Climate-Related Restrictions on Fossil Fuels

1. Major global warming problems. Some of the evidence we found supports the view that global warming will have a substantial impact upon utilities and other energy companies between now and 2010. Factors justifying pessimistic expectations include the following:

- There is enough scientific evidence that greenhouse gases (GHGs) are helping to cause alarming climatic changes to justify controls, and better monitoring technology could put the causal link beyond dispute.
- Weather over the past 150 years has been unusually mild by historic standards, and the abrupt return of extreme droughts, storms, and other such phenomena could feed anxiety over climate change regardless of whether GHGs are to blame.
- The Kyoto Protocol, the treaty requiring industrial nations to cut GHG emissions to 5% below their 1990 emissions by 2008-2012, represents the most workable approach for controlling GHG emissions and has enough public and political support to overcome opposition.
- Alternatives to cutting emissions, such as trading emissions allowances, will not be permitted to excuse industrial nations from achieving genuine GHG reductions.
- Although new technologies may enable activities such as power generation to emit fewer GHGs, it is doubtful that all the necessary reductions can be made without curtailing the use of fossil fuels.

2. No global warming crisis. Some sources cast doubt on the proposition that global warming will become a major problem for utilities and other energy companies. Reasons sceptics give for questioning its effect include these:

- Scientific evidence indicates little definite change in the earth's climate, and even if warming does occur it could help, for example by extending growing seasons.

- The role of carbon dioxide (CO₂) and other GHGs in stimulating global warming is not yet known for certain, and could be nil.
- Better monitoring technology could conclusively disprove global warming theories and/or show that any warming is natural.
- Public opinion and political considerations will bar taxes and regulatory restrictions on fossil fuels, since those would jeopardise economic growth.
- The Kyoto Protocol will either fail for want of ratification or be interpreted in ways that modify its more stringent provisions.
- If any action is required, painful adjustments within the energy sector will be minimised by recourse to voluntary GHG reductions (aided by new technologies that reduce emissions) and the trading of emission allowances.

Because the energy sector accounts for 40% of CO₂ emissions, how the climate change controversy evolves is a key variable that will influence utilities between now and 2010. Utilities could find that adjustments some are already making, such as switching from coal to gas, will suffice. Or they could be forced to make major operational and technology changes. Additionally, a climate change scare could favour non-traditional business models based on alternatives such as distributed generation.

Implications of the Research

1. Our findings indicate that qualified individuals and organisations hold conflicting views on how abundant, reliable, and environmentally acceptable fossil fuels will be between now and 2010.
2. With the outlook this uncertain, utilities are vulnerable to becoming too locked into one set of assumptions as to how things will turn out. Almost any forecast or hypothesis will be off to some degree, and the odds of being spectacularly wrong are far higher than before.
3. To succeed in the new decade, Deloitte Research recommend that utilities identify and assess the full range of possible futures prior to adopting corporate strategies, using tools designed for planning in a complex and volatile world, such as scenario-building, real options valuation, and computer modelling.
4. We also recommend that utilities become more versatile and adaptable. This entails developing systems, processes, and a culture that are suited to rapid change, making it possible to meet unexpected challenges and opportunities without delay and confusion.



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Geology, Geo-Politics, Global Warming: What's At Stake, Why It Matters

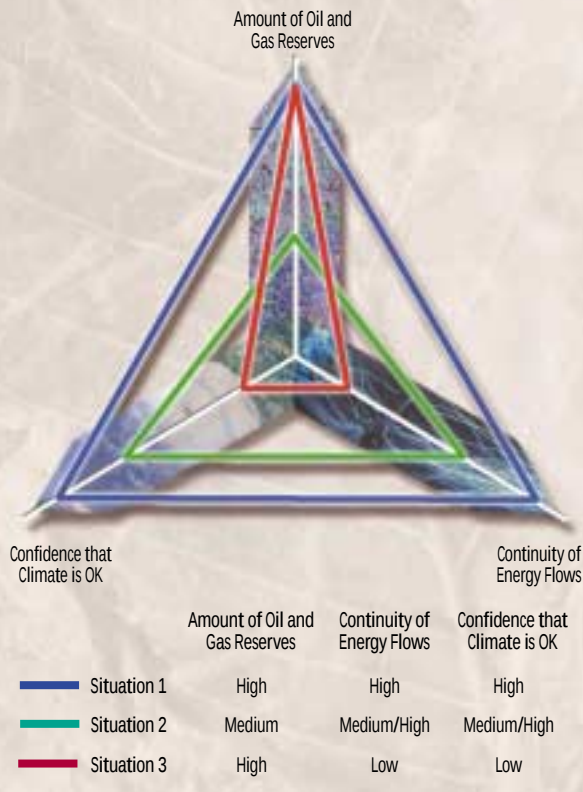
PROBLEMS IN FORECASTING ENERGY FLOWS

Few questions are more contentious or involve more unknowns than those pertaining to energy supply and demand. Various governmental and private-sector organisations address the subject in periodic projections and scenarios, including the Paris-based International Energy Agency (IEA), the US Geological Survey (USGS), the US Energy Information Administration (EIA), BP, and Geneva-based Petroconsultants. History shows their projections are often off the mark. Dr. Colin Robinson of the London-based Institute of Economic Affairs has said, "People are very bad at predicting. All the great turning points in prices have been missed by the experts".

One reason for inaccurate forecasts is the difficulty of getting all the relevant assumptions right. Supply and demand are each complex, and there is also an intricate interaction between supply and demand. The availability of supply can influence demand – if fuels are plentiful, users have less incentive to adopt energy-efficient technologies or buy smaller cars. Conversely, the amount and nature of demand can influence supply. If recessions diminish demand, oil and gas companies have less incentive to seek new sources or scour existing fields. If carbon emissions become a political issue, this is likely to bolster the popularity of cleaner fuels. But it isn't just a matter of arriving at the right numbers to plug into a model. The quality of the model matters as well. Critics often disparage the calculations that go into energy supply-demand estimates. The president of the US Association for Energy Economics has observed that "the most well-funded studies, the most prestigious experts, the most august bodies can all produce work which is simplistic and flawed".

In this part of *The Utility Executive's Field Guide to the Future* our focus is on three issues having to do with fossil fuels: (1) geology – the extent to which supplies of oil and gas will be adequate to meet demand; (2) geo-politics – the extent to which oil and gas will be produced and transported without political disruptions; and (3) global warming – the extent to which concerns about the climatic effects of fossil fuels may constrain their production, transport, and use. Exhibit 1 illustrates in simplified terms how circumstances could vary between now and 2010 with respect to these three variables.

EXHIBIT 1. POSSIBLE CONDITIONS REGARDING FOSSIL FUEL RESERVES, PRODUCTION AND DELIVERY, AND ENVIRONMENTAL ACCEPTABILITY



SOURCE: DELOITTE RESEARCH

The most positive possible circumstance for the period 2000-2010 would be one in which all three variables are at the *high* end of the range – that would mean supply and demand are balanced, energy flows are highly reliable, and the environmental effects of fossil fuel production, transport, and use are generally considered acceptable.

At the other end of the spectrum would be a situation in which all three are at the *low* end of the range – that would mean severe gluts or shortages, chronic disruption of fuel production and transport, and strong environmental objections.

In between are myriad possibilities. The simplest is that all three variables would be at the mid-point. Beyond that lie cases in which conditions are at different points on the spectrum from one variable to the next. For example, reserves could be ample whilst political unrest causes a moderate number of supply disruptions and green forces mobilise strong opposition to the use of fossil fuels.

Of course, much depends upon when and how rapidly such developments occur during the decade. Supplies could be well-matched with demand in the first half of the decade but below demand in the second half, and so on. Also, the impact of any set of circumstances is likely to differ from one market and company to the next.

Allowing for all the variations and permutations, what are the general implications of different outcomes regarding demand-supply balance, production and delivery security, and environmental concerns?

WHY DEMAND-SUPPLY BALANCE MATTERS

If the decade is marked by excess demand for fossil fuels, this would tend to benefit the energy business. Input costs would rise for downstream energy companies, but they could charge premium prices, which would produce not only increased revenues but higher earnings and shareholder returns, along with more funds for investment.

Beyond a certain point, though, high fossil fuel prices would hurt because customers would balk at the expense and the economy would suffer from fuel shortages and inflation. Further, chronic unmet demand would encourage government intervention

and the development of substitutes such as biomass fuels and various kinds of micro-generators. The latter would not *necessarily* be bad, since energy companies could co-opt such innovations, but it would present them with unfamiliar challenges and risky strategic decisions.

If the energy sector were at the opposite extreme much of the time between now and 2010, utilities and other energy companies would tend to suffer because the lower prices would create more of a buyer's market. Profits would shrink and make the industry less attractive to capital markets. Consuming nations and customers would not necessarily benefit indefinitely, however, since prolonged low prices could cause social and political upheavals in producing nations, bankrupt energy companies, or otherwise destabilise supply.

WHY PRODUCTION/DELIVERY RELIABILITY MATTERS

If energy flows are uninterrupted throughout the decade, this would permit demand and supply to interact without artificial complications. Generally a smooth flow of energy favours consuming nations and customers, except if supplies are so generous and prices are so low that the energy sector begins to buckle. Intentional production cutbacks by definition favour producers' interests, so long as they do not lead to countermeasures by consuming nations or new competition. Cutbacks, stoppages, or irregular deliveries attributable to forces such as political turmoil or weather damage are another story. These can disadvantage producers and potentially the rest of the energy industry as well as end users.

WHY CLIMATE RESTRICTIONS MATTER

If fossil fuel production, transport, and use are considered environmentally benign, this would tend to favour the more conventional segments of the energy business – those relying upon fuels such as coal and oil and using facilities such as power plants, dams, transmission towers, and pipelines. They would not have to cope with environmental harms, negative publicity, and restrictions. Such circumstances would impede the commercialisation of alternative fuels and distributed generation.

If, at the other extreme, the decade brings alarm about fossil fuels' environmental effects, this would disadvantage conventional fuels and infrastructures while opening new opportunities for "green" fuels and mechanisms deemed less injurious to humans and the planet. The nature and intensity of the objections would determine specifically which interests were helped or hurt – for example, the fortunes of gas-fuelled small generators would depend upon the level of concern about CO₂ emissions, the fortunes of hydropower would depend upon the extent to which big dams are considered environmentally harmful, and the fortunes of nuclear power would depend upon the levels of concern about radiation.

The spectrum of environmental issues pertinent to the energy sector is extensive. In this part of the *Field Guide* we focus upon the matter of global warming.

Patterns in the Welling & Co. Survey Responses

With respect to each of these issues, the results of the Welling & Co. survey show that, on the whole, the respondents from utilities, corporate energy users, and engineering firms anticipate that as of 2010 energy supplies will be adequate to meet demand, energy production and delivery will not be subject to interruptions, and fossil fuels will not be caught in disabling environmental controversies.

Although the preponderance of the Welling & Co. survey results supports the view that energy will be plentiful and non-controversial, there were some conflicting signals. The responses on some points indicate a degree of unease, particularly about energy supplies and green issues. Further, although our other research found ample confirmation for the optimistic scenario, we have also turned up a variety of factors suggesting less upbeat forecasts and expectations. In the discussion that follows we explore the different perspectives and their implications.

Demand Side of the Equation

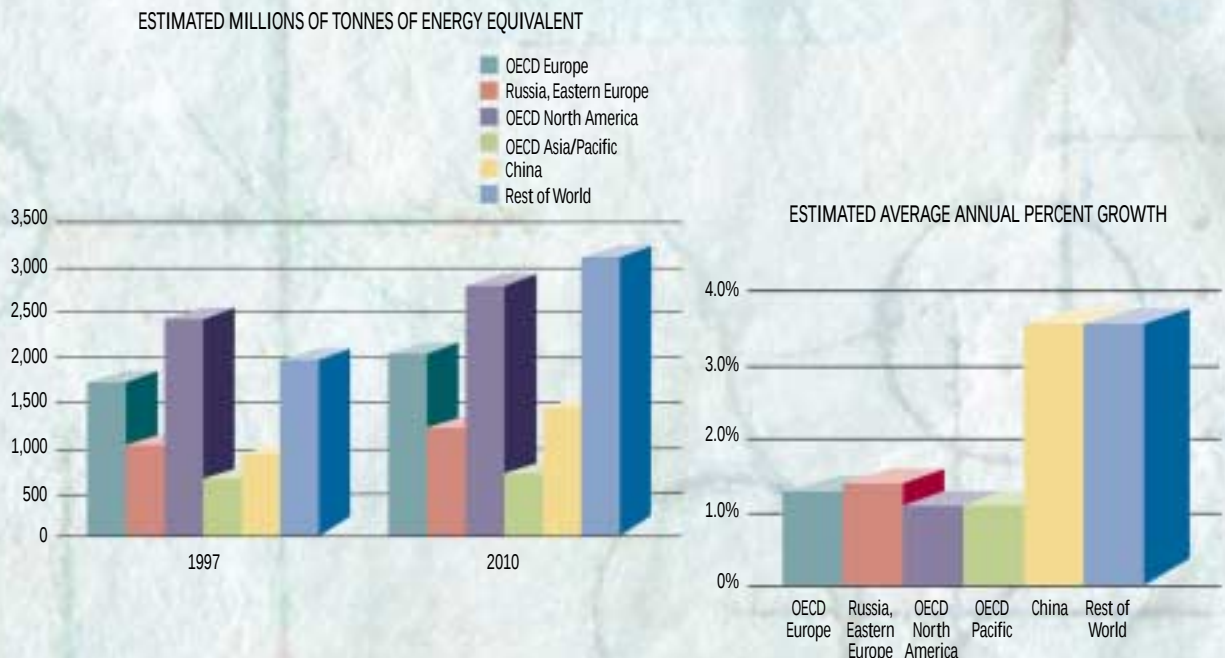
Generally the analyses conducted by governments and other organisations indicate continuing strong growth in energy demand. The IEA's current reference scenario has world energy demand rising at an average annual rate of about 2% between 1997 and 2010, for a total increase over the period of about 30%. The estimate is part of an updated 1997-2020 forecast presented in the IEA 2000 annual *World Energy Outlook*¹ publication. By 2020, IEA project energy demand rising by 57% over the 1997 level.

IEA's reference scenario assumes an average annual GDP growth rate of about 3% worldwide (with actual data for the early years in the period). The model also assumes a slowdown in the average annual population growth rate. The IEA have incorporated a variety of global warming policies adopted or announced by industrial countries but have not made any assumptions about future emission-control initiatives.

The charts show the IEA's estimated 1997-2010 energy demand and annual demand increases for six geographic areas. IEA project moderate growth in demand for Western Europe, North America, Japan, Australia, and New Zealand, but much steeper growth in developing nations – about 3.6% in China, 4.5% in India, and 4.6% in East Asia (outside of Japan), and South Asia. Furthermore, they project growth rates nearly as high through 2020.

"OECD North America" consists of the US and Canada only – the IEA place Mexico in their Latin America category for modelling purposes. "OECD Pacific" consists of Japan, Australia, and New Zealand. In the "Rest of World" category are East Asia, South Asia, Africa, Latin America, and the Middle East.

EXHIBIT 2. IEA'S ESTIMATE OF WORLD ENERGY DEMAND, 1997 - 2010



and gas in the ground?

Debate Over Demand-Supply Balance

OVERVIEW OF OPTIMIST-PESSIMIST DISPUTE

Although little-noticed, there is an increasingly fierce debate amongst experts as to how much conventional oil and gas reserves are available for production. The disagreement concerns both oil and natural gas, but focuses on oil. At issue is how long it will be before the world faces the depletion of the oil stocks that are inexpensive to produce, and must rely upon more costly forms of energy. To put it another way, the issue is not whether the world is running out of oil, but whether the world is running out of cheap oil.

Conventional oil is oil produced by cheap and fast drilling into underground hydrocarbon reservoirs, whilst unconventional oil is oil in hard-to-reach places, oil not produced through drilling, and/or sources that require additional processing to produce synthetic crude. Examples of unconventional oil are oil from coal and shale, extra heavy oil, polar oil, and deepwater oil (depths beyond 500 meters).

Although the proportion of oil used in electricity generation is low (except in Japan, where it accounts for close to 20%), how much conventional oil remains still matters to utilities. First, the way oil prices affect the upstream portion of the energy business can influence the incentives for companies in the energy business to move up or down the value chain. Second, oil prices can have significant impacts upon economic conditions generally, which influences strategic options for all energy companies. Third, if conventional oil reserves were to run low, this could put upward pressure on the price of natural gas, the fuel that is increasingly vital to electricity generation.

Pessimists set the amount of conventional oil reserves at a comparatively low level, and argue that very little new oil will be added to existing proven reserves via new discoveries or new ways of extracting oil from existing fields. Moreover, pessimists contend oil production starts to decline once half the reserves are gone, a point they say the world will reach before 2010. On the other side

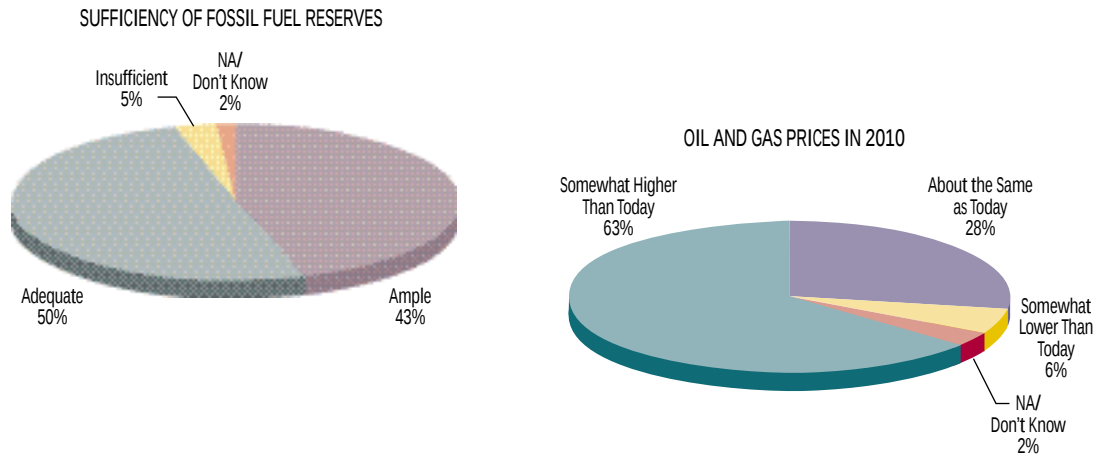
are optimists who see conventional oil reserves as constantly increasing because of new discoveries and new methods of extracting oil from existing fields. They discount the significance of the argument that production tapers off once the half the reserves are gone because they believe the halfway point will keep getting pushed farther into the future for many decades. Not part of the debate but still relevant is a renegade theory holding that even the optimists are drastically underestimating the amount of oil waiting to be discovered.

To some extent the controversy can be attributed to the different perspectives of geologists and economists. As articulated by retired US Congressional Research Service geologist Joseph Riva in the *Hubbert Center Newsletter*, economists are "oil resource optimists" who believe "the earth's resources are huge and unknowable", whilst geologists see themselves as people "whose careers depend upon putting numbers on oil accumulations". Economists think the forces of market demand and technological ingenuity can expand the definition of what is possible, says Riva, and fault geologists for chronically underestimating oil reserves because "they treat as a quantity what is actually a dynamic process driven by growing knowledge". According to Riva, geologists react by grouching that "nothing is impossible unless you have to do it yourself".

PERTINENT SURVEY AND INTERVIEW RESPONSES

The respondents to the Welling & Co. survey generally subscribe to a positive outlook about energy availability, but with some reservations and hedging. As noted in Part 1, oil and gas reserves came in third from last in the ranking of factors likely to affect the utility business in the 2000-2010 period. This implies that neither shortages nor gluts will be a major issue. Other responses are mainly positive, though with some room for unfavourable developments.

EXHIBIT 3. WELLING & CO. SURVEY RESPONSES RELEVANT TO FOSSIL FUEL RESERVES



SOURCE: DELOITTE RESEARCH/WELLING & CO. SURVEY

Half the respondents agreed that energy supplies will be "adequate" assuming no unusual needs or situations, and 43% approved the most positive view, that supplies will be "ample". Around six in 10 think oil and gas prices will be "somewhat higher than today" and over a quarter expect price levels to be "the same as today". At the time the survey was conducted in 1999, oil prices were moving upwards after a long period of historic lows and had reached the \$20-25 range. Admittedly it is difficult to pin down what specific price the result implies, but it seems unlikely the respondents expect *dramatic* increases because, as discussed in Part 4, they are comparatively sanguine about the economy's performance between 2000 and 2010.

If anything, the industry participants and experts we interviewed were more confident than the Welling & Co. survey respondents. The following are illustrative of the many "no surprises" assessments we collected in our in-person interviews:

- A European corporate energy manager told us that, "in 2010, the perception will be that fuel supplies are sufficient, because every year they discover more and more reserves of fuel".
- According to a German utility executive, "a sufficient supply of gas, oil, and coal can be expected in 2010 and consequently prices in the international markets will be stable for the upcoming decade".

- Another German utility executive believes "the physical availability of reserves is not a problem". He does not think fossil fuel reserves will be used up, because before that point is reached, technological progress will enable utilities to use alternative energy.
- An EC staff member said "LNG and GTL technologies along with high-pressure pipelines should make remote natural gas reserves more competitive to exploit and, thereby, increase global supplies available for commercial use".
- Another EC staff member predicts "natural gas and coal will remain the dominant players, with nuclear declining in importance but remaining significant".
- Likewise, a Japanese utility executive believes that in Japan, "the fuel portfolio in 2010 will hardly change from now".
- Finally, a US utility CEO said, "I foresee no supply problems in the next 10 years – there are always forecasts that gas and oil supplies are running out, but I don't think that will actually pose a problem in the next 10 years".

Decade of Depletion?

PESSIMISTIC SCHOOL OF THOUGHT REGARDING OIL AND GAS RESERVES

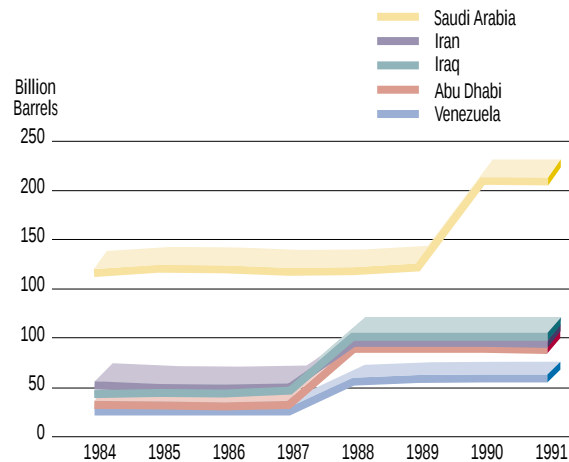
A band of sceptics question rosy energy supply scenarios. At Websites such as www.oilcrisis.com, www.petroplan.co.uk, and <http://hubbert.mines.edu> they sound alarms about the outlook for meeting energy demand in the new decade. Dr. Colin Campbell and Jean Laherrere are geologists who have been among the most successful of the pessimists in gaining attention in both public and industry forums. Campbell and Laherrere made a splash when they set out their case in a 1998 *Scientific American* article, "The End of Cheap Oil". In mid-1999, Campbell appeared before a committee of the British House of Commons and gave a talk entitled "The Imminent Peak of World Oil Production". The optimistic projections issued by the USGS in 2000 were assailed by Campbell in an *Oil and Gas Journal* article and by Laherrere in a paper presented at Energy Resource 2000, a World Energy Council virtual conference co-sponsored by Deloitte & Touche and Deloitte Consulting (www.energyresource2000.com).

POSSIBLE HIGH-SIDE BIAS IN REPORTING

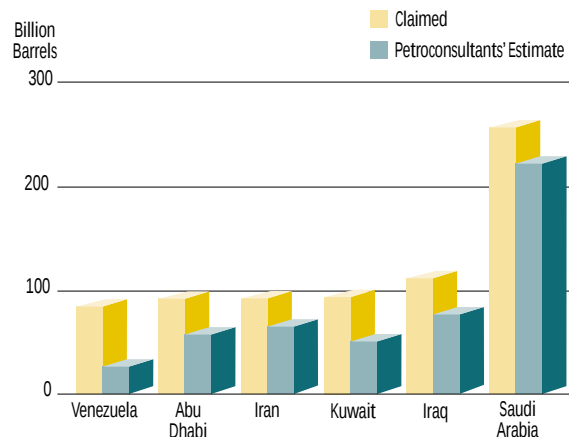
Pessimists charge that official reserve estimates are vastly inflated. Campbell and Laherrere argue the ultimate total reserves of conventional oil are 1.8 trillion barrels, half a trillion under more optimistic assessments. In tearing down the more hopeful version they cite a 300 billion barrel (62%) leap in OPEC's reported conventional oil reserves that occurred when quotas were imposed in the late 1980s and, they say, it became advantageous for each country to show the highest possible base from which cuts would be assigned. They also claim that many countries report the same reserves year after year, implying that fields are being worked but the volume of oil within them remains constant. During his House of Commons appearance Dr. Campbell said 60 countries reported unchanged numbers in 1998. Pessimists deny this can be explained either by additional discoveries or by natural replenishment.

EXHIBIT 4. JUMP IN REPORTED OPEC OIL RESERVES

RESERVE REVISIONS QUESTIONED BY CAMPBELL AND LAHERRERE



ALLEGED OVERREPORTING OF OIL RESERVES BY KEY OPEC MEMBERS
(BILLION BARRELS OF REPORTED OIL RESERVES AS OF 1996)



SOURCE: DR. COLIN CAMPBELL, "A GUIDE TO DETERMINING THE WORLD'S ENDOWMENT AND DEPLETION OF OIL," www.oilcrisis.com

QUESTIONS ABOUT AMOUNT OF OIL LEFT TO FIND

Pessimists see the reserve situation as static and advise against pinning hopes on new discoveries. Campbell and Laherrere say world discoveries peaked in the 1960s. They claim 80% of the oil produced today comes from fields discovered before 1973, and assert that the rate of discovery has slowed to the point where the world finds just one barrel of oil for every four it uses. In their *Scientific American* article they stated that "There is only so much crude oil in the world, and the industry has found about 90 percent of it".

In his Energy Resource 2000 paper, Laherrere criticises the latest USGS World Petroleum Assessment that projects major new discoveries in coming years. "It is replete with contradictions and downright errors", he complains.

What about exciting new finds such as the giant Kashagan East well in the Caspian? Dr. Campbell is dismissive, saying it is "a solitary huge structure and does not herald further major discoveries capable of having a world impact".

DOUBTS ABOUT THE IDEA THAT NEW TECHNOLOGY CAN IMPROVE RECOVERY

Increasing recovery is no answer, either, according to the pessimists. Campbell and Laherrere insist that many of the increases in production credited to improved recovery are actually due to reporting irregularities. Their argument: companies systematically underreport

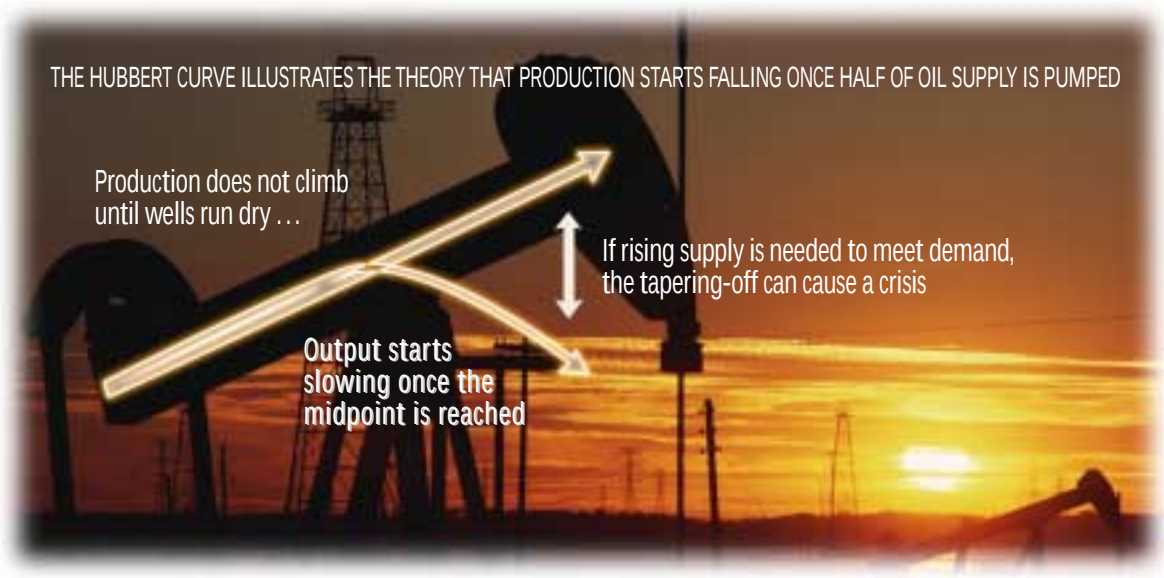
the oil in newly-discovered fields and then raise their estimates without backdating the correction. The jump is erroneously taken to mean companies are getting more out of the fields when actually they are revealing the true recoverable amounts they knew were there all along.

Campbell and Laherrere do not deny that new technologies achieve some improved recovery, but they offer three qualifications: First, oil companies routinely make aggressive reserve estimates on the assumption better techniques will come along that will enable them to deliver those amounts, so improved recovery is already built in. Second, the fields where recovery can be increased typically are small. Third, rather than expanding the total amount of oil recovered, the new techniques often simply drain the originally-stipulated amount faster.

POTENTIAL PRE-2010 DECLINE IN PRODUCTION OF CONVENTIONAL CRUDE

A key aspect of the pessimistic outlook is the Hubbert curve. Named for the late M. King Hubbert, a Shell geologist, this bell-shaped curve is said to illustrate the production of oil from any large field, and, in aggregate, for the world as a whole. The Hubbert curve indicates that production begins to taper off once half the oil is gone – producers do not continue pumping away right up until the end. The theory's validity got a lift when Hubbert used it in 1956 to correctly predict that US oil production would peak around 1970.

EXHIBIT 5. HUBBERT CURVE AND OIL PRODUCTION BEHAVIOUR



SOURCE: M. KING HUBBERT

Campbell and Laherrere say their 1.8 trillion barrel estimate of conventional oil reserves omits errors from inflated reserve reporting, illusory new discoveries, and exaggerated recovery improvements. If their estimate is indeed accurate, it would mean the midpoint will come when 900 trillion barrels of oil have been produced. Campbell and Laherrere think the world could be there soon.

In their *Scientific American* article the two say, "Barring a world recession, it seems most likely that world production will peak during the first decade of the 21st century". In his House of Commons presentation and on subsequent occasions, Campbell describes a "reasonable base case" scenario in which world production starts to tail off at the rate of 3% annually around 2008.

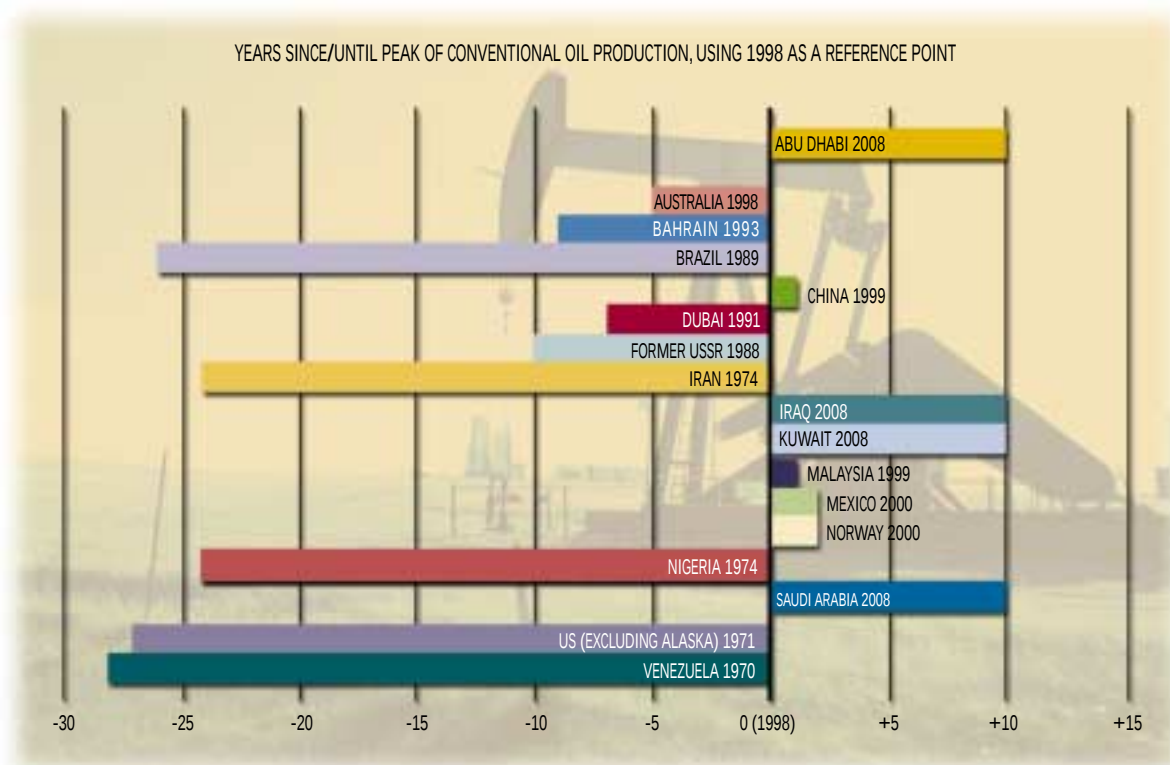
CONSEQUENCES IF DECLINE STARTS FIRST IN NON-OPEC FIELDS

Although Campbell and Laherrere believe the overall peak will come towards the end of the decade, they say it will be that late only because of Middle East oil production. Outside the Middle East, they

argue, output declines will hit with growing force early in the decade, making it progressively more obvious that for the time being the Gulf region has the world's only fields still capable of producing more of a disappearing resource. "Already the Middle East faces less competition every day that passes", claims Campbell. Obviously picking up the slack caused by slipping production elsewhere would give enormous leverage to the Middle Eastern OPEC members (assuming the Middle Eastern countries are able to expand their capacity sufficiently to permit increased output).

Supporting the Campbell-Laherrere thesis, a group of researchers at England's Reading University argued in a late-1999 letter to the International Association for Energy Economics (IAEE) that UK conventional crude is about to peak, based on figures in the UK government's "Brown Book". The researchers contend that, whilst many analysts appreciate that the UK is a mature province where new technologies will not shift the peak date by much, "what is missing... seems to be an appreciation that most of the world is just like the UK, mature places where peaking is not far off".

EXHIBIT 6. DR. CAMPBELL'S SUMMARY OF CONVENTIONAL OIL PRODUCTION PEAKS BY COUNTRY



SOURCE: DR. COLIN CAMPBELL, "GLOBAL CONVENTIONAL OIL ENDOWMENT", www.oilcrisis.com

According to the base case scenario Dr. Campbell presented at Westminster, in 2001 the Middle East's production approaches the 38% share that prevailed at the time of the 1973 oil shock. At that point Middle East countries get the confidence to impose much higher prices. Warned Campbell: "They may even get such confidence sooner".

Since then Dr. Campbell has speculated that OPEC's 1999-2000 production cutbacks may be attributable to the cartel's growing realisation that the end of its reserves is coming into view rather than to a simple desire to manage the price of still-abundant resources: "This rise may in fact have represented the unseen iron hand of depletion rather than any particular OPEC action". And in a March 2000 *Oil and Gas Journal* article, he imagines how the end game might begin during the early part of the new decade:

When Air Force One makes a new panic tour to Norway, Mexico and the Middle East, it meets ashen faced oilmen saying that they have been working night and day to meet their quotas, but were unable to do so. The world, including OPEC, gradually appreciates that it faces a losing battle in trying to offset the depletion of the large, old, low-cost fields.

In a March 2000 *Oil and Gas Journal* article Dr. Campbell summarised his projections of how the Middle East's production share might grow from its level of 30%:

Unlike in the 1970s, this time it is set to continue to rise as there are no new major provinces in sight. Share will likely reach 35% by 2002 and 50% by 2009. By then, the Middle East too will be close to its depletion midpoint, and unable to sustain production much longer irrespective of investment or desire.

Generally people in the oil and gas industry do not embrace the theories of Campbell and Laherrere, but there are exceptions. Stressing that he was giving his personal opinion, Richard Hardman, Amerada Hess vice president for exploration, said on a BBC programme in November 2000: "I think there will be a real crunch. There will be a competition for this scarce resource – the oil. It means that there could be famines and wars".

SIMILAR ISSUES INVOLVING NATURAL GAS RESERVES

What do the pessimists have to say about natural gas? They believe the Hubbert Curve applies to gas as well as oil, although with some modifications.

In an article posted at the www.oilcrisis.com Website, Dr. Campbell explains:

Gas depletes very differently from oil due to its higher molecular mobility and recovery factor. Instead of following a bell curve, production is capped by the limits of the pipeline and the market. In an unregulated market, such a plateau runs its course with few signals that it is about to end, it being often cheaper to produce the last cubic foot than the first. The plateau ends not in a slope but in a cliff.

In another article posted at the Website, Campbell and Laherrere calculate that the peak of world gas production will occur around 2018. Within the logic of the pessimists' assumptions, the prices of natural gas would be likely to rise well ahead of the peak, not only because of efforts to substitute gas for oil, but because the experience of seeing oil production sink between 2000 and 2010 would persuade the world that gas, too, is a dwindling resource.

SUMMARY OF PESSIMISTIC VIEW

The pessimists predict the world's supply of cheap oil will begin declining long before it is gone, and that Middle Eastern OPEC countries will acquire leverage they have not enjoyed since the 1970s because their production will be the last to peak. They foresee as possibilities "radical" oil price increases, financial crises, and geopolitical tensions. The world will have plenty of means for coping with the situation, say the pessimists, but they emphasise the need for advance planning, accelerated R&D, and concerted action focusing upon unconventional oil reserves, gas to liquids technology, substitution of natural gas, safer nuclear power, cheaper renewable energy, and oil conservation programs.

Decade of Discovery?

OPTIMISTIC RESERVE PROJECTIONS

Worries about the adequacy of energy supplies are not reflected in most projections published by major national and international energy organisations. A draft report by the Washington-based Center for Strategic and International Studies (CSIS) entitled *The Geopolitics of Energy Into the 21st Century* begins with the following overview:

As we approach the 21st century, the outlook for energy resources is strongly conditioned by expectations of plenty, rather than scarcity. There are dissenting views, but the prevailing assessment among energy experts is that world energy supply will be more than adequate to meet demand for the foreseeable future.

The US Energy Information Administration (EIA) in its *International Energy Outlook 1999* report says that, at least through 2020, "resource availability does not limit the development of energy markets".

The USGS in 1994 released projections that are at the high end of the figures central to the debate. The agency estimates that ultimate recoverable oil reserves are in the 2.1-2.8 trillion barrel range, and favour the figure of 2.3 trillion. Estimates of how long it might take to exhaust a stock of that size vary, but some run to many decades or even centuries.

Recent developments arguably lend credence to the optimistic view. In 2000 reports circulated that the Kashagan East field in the Caspian Sea could hold 30 billion barrels of oil, which would make it second only to Saudi Arabia's largest field. And there was speculation the melting of ice in the shallow Kara Sea off Russia might make it possible to drill into gas deposits larger than those on the Russian mainland.

CRITICISM OF PESSIMISTS' CASE

Optimists see Campbell and Laherrere as simply the latest in a long line of prognosticators who underestimate reserves and overestimate prices. Michael Lynch, Executive Director of Asia Energy and Security at the Massachusetts Institute of Technology (MIT) and President of the US Association of Energy Economics, argued in a 1999 IAAE Newsletter article that nearly all production

forecasts since the late 1970s have called attention to the same sorts of concerns featured in Campbell and Laherrere's scenarios and, whilst much of this is true, "it has been true for 20 years, and yet still non-OPEC production rises".

As for prices, Lynch contends that the concern about increases resembles the conditions that took hold in the late 1970s, when "many analysts became convinced that real oil prices must inevitably increase, on the order of several percent per year, despite the fact that such trends had never been observed".

Reviewing the case now being made by pessimists, Lynch said, "it is disheartening to see the degree to which even the most basic, obvious lessons have gone unlearned, not just by the media, but by people who are supposed to be the experts".

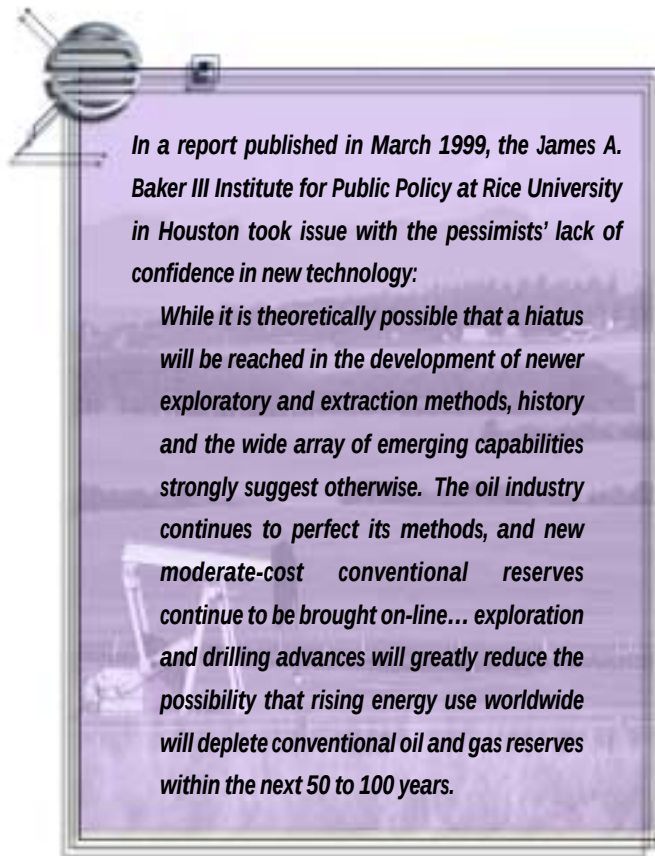
FACTORS PROMOTING CONSERVATIVE RESERVE ESTIMATES

Regarding the alleged bias toward overstatement in official reserve estimates, optimists argue the situation is not so clear-cut. They point to evidence of factors that arguably cause an understatement of reserves. For example, Lynch contends finance ministry officials in oil-producing states sometimes favour lower estimates to curb politicians' propensity to overspend projected revenues. He also argues that forecasters tend to err on the conservative side to reduce their exposure, particularly if the consensus view is conservative. Additionally, conservatism may intrude through reporting anomalies. USGS found that during the 1980s and early 1990s nearly a thousand oil and gas discoveries were registered for which no reserves were recorded.

IMPACT OF HUMAN INGENUITY AND MARKET FORCES

The central issue, though, is the optimists' faith that technology and market forces will work wonders if oil availability becomes a problem and prices rise, in the future as in the past.





In mid-2000 the USGS released their updated World Petroleum Assessment, in which they announced new estimates for reserves outside the US. Their bottom line: "Overall there is a 20 percent increase in undiscovered oil and a slight decrease in undiscovered natural gas". Said the agency director: "The big news is that potential additions to reserves from reserve growth are nearly as large as the estimated undiscovered resource volumes".

QUESTIONS ABOUT OPEC'S ABILITY TO DICTATE WORLD OIL PRICES

What about the notion that Middle Eastern oil producers will be able to dictate oil prices? "The day when OPEC's financial power is restored remains distant", according to Michael Lynch.

Some optimists apply their more dynamic view to the question of production patterns. In a 1997 paper published in the *Journal of Petroleum Technology*, petroleum engineer Paul Taylor argued that market responses to rising oil prices cause production to depart from the symmetrical decline portrayed by the Hubbert curve and move upwards again, creating an additional hump. He theorised that production would peak a second time at some point after 2025.

Lynch accuses Campbell of implicitly acknowledging that reserves are constantly being augmented by periodically ratcheting up his reserve estimates. Lynch claims Campbell's 1997 estimate of 1.8 trillion barrels in reserves is 150 billion barrels higher than an estimate he published in 1991, and 150 billion barrels is about the amount of oil consumed in the intervening years – "implying," states Lynch, "that he sees the oil industry at a steady state – replacing reserves as fast as they are being consumed".

"DEEP EARTH" THEORY THAT OIL AND GAS DEPOSITS ARE UBIQUITOUS AND GROWING

There is another view on the question of the planet's oil reserves which picks up where the optimists leave off, but it is deemed so odd it is seldom raised against the pessimists. Basically it holds that oil and gas could be found all over the earth if only oil companies would abandon their mistaken ideas on where these resources are most likely to reside.

The theory has been developed by Thomas Gold, the retired director of the Cornell Center for Radiophysics and Space Research. Dr. Gold has held research and teaching posts at Cambridge and Harvard, and is both a Fellow of the Royal Society and a member of the National Academy of Sciences. He is known for discomfiting experts in fields outside his own by proposing unconventional theories that in some cases have proven valid.

As laid out in *The Deep Hot Biosphere*², Gold believes oil, gas, and coal come from hydrocarbons deep in the earth, 100 to 300 kilometres down. As he notes wryly, "This depth is nearly 100 to 300 kilometers deeper than proponents of the biogenic view would place the origin of petroleum". Chemical processes associated with the intense heat and pressure of those depths release liquids and gasses which work their way upwards because they are lighter than the rock of the earth's crust. In places nearer the surface, the upwelling materials are trapped, and these are the areas tapped by drillers.

This "deep-earth gas theory" contradicts the accepted view, which is that oil, gas, and coal are fossil fuels that come from prehistoric life forms buried in sedimentation. One objection to Gold's theory is that oil and coal contain signs of biological life –

molecules associated with the breakdown of organic substances. If fossil fuels are *not* reworked plants and algae, how did these biological molecules get mixed in? His answer is that the bio-molecules are the remains of microbes that feast on the oil once it gets to within 10 kilometres or so of the surface. His contention, then, is that there is a so-far undocumented subterranean realm of oil-eating bugs thriving in rock pores and fissures at depths and in temperatures generally thought impossibly hostile to life. "Hydrocarbons are not biology reworked by geology", Gold insists, "but rather geology reworked by biology... hydrocarbons are primordial, but as they upwell into the earth's outer crust, microbial life invades". Gold dubs this his "deep hot biosphere theory".

The views Gold propounds stand conventional thinking on its head. Rather than coming from material that started out on the earth's surface and then sank downwards, he says oil, gas, and coal start out far below the surface and move up. Rather than being biological material transformed by chemical processes, he believes they are chemical materials transformed by biological processes.

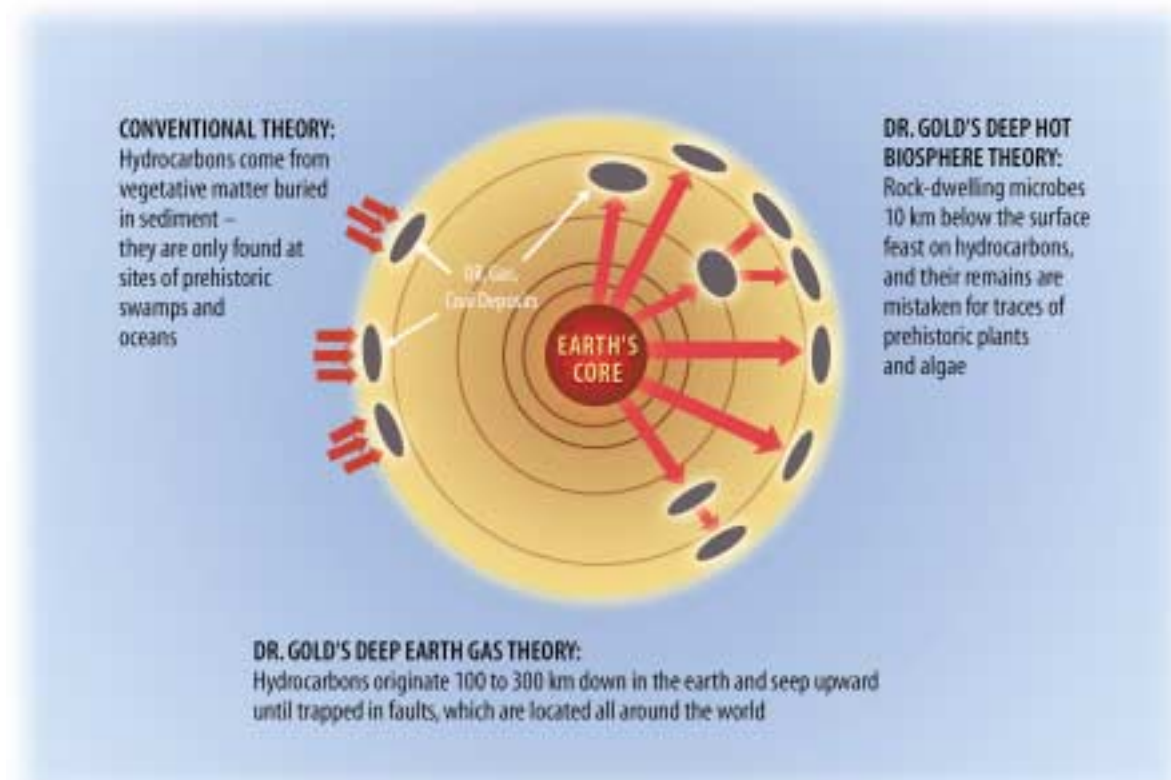
And rather than representing the relics of a now-defunct process, he insists the so-called fossil fuels are still forming.

A key implication of these theories is that stocks of oil, gas, and coal are in places other than the sedimentary rocks that mark the location of prehistoric jungles and oceans. Yet isn't this where they have always been found? Gold's answer is that this is only because of where the energy industry looks. "Nearly all wells were drilled in sedimentary rocks", he shrugs, "so nearly all oil was produced from sedimentary rocks".

Gold's ideas are regarded as highly speculative or wrong by geologists and biologists. However, he is not entirely without evidence.

One example he cites was his late 1980s discovery of oil in a Swedish granite formation, not a location of interest to the typical oil company. He organised the drilling project to show that his theories could be used to dramatically rewrite the rules of the oil business: "I would have to make a sound case that this valuable commodity would prove to be far more widespread around the globe than had

EXHIBIT 7. DR. GOLD'S REVISIONIST THEORIES REGARDING HYDROCARBON ORIGINS



SOURCE: DR. THOMAS GOLD, THE DEEP HOT BIOSPHERE

been previously supposed and that the dependence of many countries on oil exploration would, as a consequence, be greatly reduced". Two wells Gold drilled produced oil. Production reached 84 barrels when drilling was stopped by massive amounts of a strange smelly sludge Gold thinks is the product of rock-dwelling microbes. He contends another hole could have been drilled in such a way as to avoid the sludge and extract more oil, but his investors begged off. Gold believes the experiment deserved to be treated as an exciting breakthrough, but neither the industry nor the scientific community has received it that way.

Another proof Gold claims is the refilling of certain oil fields in the Middle East and Gulf of Mexico. In these independently-reported cases, new oil has appeared in reservoirs from which oil was being drawn. In the mid-1990s, a 4-D image of the Eugene Island field off Louisiana revealed a stream of oil gushing from a fault into the reservoir, its origin unknown. Gold attributes such phenomena to situations in which the field being worked lies atop one or more deeper reservoirs which feed new oil upwards as removal of the fluid above changes the pressure. He suggests such replenishment explains at least some of the continual upward revisions of reserve estimates that Campbell and Laherrere ascribe to bogus reporting and optimists ascribe to new information and better technology.

SUMMARY OF OPTIMISTIC VIEW

Optimists condemn the Campbell-Laherrere vision of imminent oil shortages and skyrocketing prices as incorrect and irresponsible. At a 1999 meeting of the British Institute of Energy Economics, Lord Lawson, former UK Secretary of State for Energy and former Chancellor of the Exchequer, dismissed the pessimists' scenarios as "gloom and doom" forecasts and "scare mongering".

Summing up the optimistic view, EIA states in its 1999 International Energy Outlook that, "When undiscovered oil, efficiency improvements, and the exploitation of unconventional crude oil resources are taken into account, it is difficult not to be optimistic about the long-term prospects for oil as a viable energy resource well into the future".



Decade of Dependence?

REVISED IEA LONG-TERM OIL SUPPLY MODEL

The International Energy Agency has formulated a set of estimates that constitute a third path the world could follow over the next 10 years with respect to fuel stocks. In updating its long-term oil-supply model for the 1998 *World Energy Outlook*, the IEA took note of the clash between pessimists and optimists. After considering the arguments, they came up with what they describe as a synthesis of the static and dynamic views. The reworked IEA model portrays a future in which production of conventional crude continues to increase throughout the decade but only because certain Middle Eastern OPEC nations are able to pick up the slack left by others. The world is dependent upon these few sources for the oil needed to keep pace with demand. Even their production then begins tapering off a few years later. Although more positive than what the pessimists foresee, such circumstances could still entail instability five to ten years out, as the IEA notes.

PESSIMISTIC ASSUMPTIONS ON EXISTING RESERVES AND PRODUCTION RATES

IEA adopted the Campbell-Laherrere proposition that the distinction between conventional and unconventional reserves is important due to the differences in their production costs. The IEA also bought into the notion that production tapers off after half the reserves are gone. Rebuking the optimists for failing to address the issue of production rates, the IEA said, "one cannot simply assume that world production will remain flat and then suddenly fall to zero when reserves are exhausted". The IEA note that in 1996 one of their studies projected that UK offshore production would peak in 1999 and Norwegian offshore production would peak in 2000.

OPTIMISTIC ASSUMPTIONS ON ULTIMATE RECOVERABLE RESERVES

The IEA agreed with the optimists that increases in reserve estimates are likely due to improved information and technology. Although it used the pessimists' 1.8 trillion barrel reserve estimate as a starting point, it then adjusted that upwards, deciding that the true recoverable amount of conventional crude could fall in the range of

2-3 trillion barrels. It chose 2.3 trillion as the outer limit of recoverable reserves for the business-as-usual scenario.

POST-2010 PRODUCTION PEAK

The upshot is that the IEA agrees with Campbell, Laherrere, and other pessimists that the end of cheap oil is coming, but it puts the production peak five years farther out. The IEA reference case has world conventional oil production peaking around 2013-2014, which is when its model says half of the 2.3 trillion barrels will have been produced. The IEA add that if ultimate recoverable reserves turned out to be only 2 trillion, the peak point would come in 2010, and if the number turned out to be 3 trillion, the peak point would be delayed to 2020. The report states "The general conclusion is that conventional oil production is likely to peak sometime between 2010 and 2020".

POTENTIAL FOR DISRUPTIONS AS OPEC LEVERAGE GROWS

The IEA reference case assumes that conventional crude oil production by OPEC's Middle Eastern members rises from 27% in 1996 to 51% in 2010. This is not greatly different from the pessimists' projections. As in the pessimists' scenario, then, the IEA assume the Middle East's leverage will be growing steadily. Summing up the situation in an understated way, the IEA declare that "During the period up to 2014, in which Middle East OPEC increases its share of total oil supply, the potential for disruptions in world oil supply increases".

Facing a replay of the 1970s, consuming nations would undoubtedly strive to develop new alternatives to reduce their dependence upon the Middle East. However, IEA observe that readying unconventional production to take up the slack once conventional production peaks "will require many multi-billion dollar greenfield production sites to come on stream". For the transition from conventional to unconventional sources to run smoothly, developmental efforts would need to begin early and adhere to schedule – conditions that might be hard to assure. "The potential clearly exists for mismatches between world oil supply and demand because of the long lead times involved", the IEA report says.

Summary of Differing Assumptions About Reserve Sufficiency

The Deloitte Research review of industry and other sources shows that world reserves of conventional oil and gas are generally reckoned to be sufficient to meet demand for many years, even given soaring demand in Asia. Moreover, if a novel theory about the origins of fossil fuels turns out to be correct, it would mean the world has far more energy than previously thought. However, there are

pessimistic views about the world's store of fossil fuels that suggest we are about to run low on cheap, easily-recoverable oil. If the end of cheap oil does come into view, it could hurt the world economy and drive up the price of natural gas, which has become popular for generating electricity. Exhibit 8 highlights the differing opinions on oil reserves.

EXHIBIT 8. CONFLICTING VIEWS ON CONVENTIONAL OIL RESERVES

	RESERVES ARE DWINDLING (CAMPBELL/LAHERRERE)	RESERVES ARE ADEQUATE IF NOT PLENTIFUL (VARIOUS)	RESERVES ARE PLENTIFUL AND GROWING (GOLD)
OVERALL SITUATION	Production will peak soon, first in non-OPEC fields, giving OPEC tremendous leverage.	World energy supply is adequate to meet demand for the foreseeable future.	Faulty theories about the origin of oil and gas lead the industry to miss how much is out there.
ULTIMATE RESERVES OF CONVENTIONAL OIL	1.8 trillion barrels	2 - 3 trillion barrels and rising	No specific estimate
WORLD'S PEAK PRODUCTION YEAR	Perhaps as early as 2008	Possibly many decades	Depends on whether oil industry changes its views on where to drill.
RELIABILITY OF RESERVE ESTIMATES	OPEC nations overstate reserves. Many nations pad reserve estimates and/or show no year-by-year depletion.	There is underreporting because some finds have been registered with no estimate of reserves.	All estimates are far too low – they fail to account for vast undiscovered supplies and for natural replenishment.
PROSPECT OF FINDING NEW FIELDS	Discovery rate is falling. About 90% of all crude oil has been found.	New technologies have produced major discoveries and will continue to do so.	Vast amounts will be found if a different theory of where to look is accepted.
PROSPECT OF EXTRACTING MORE FROM EXISTING FIELDS	Many alleged recovery improvements are due to companies raising initial artificially low estimates. To the extent new technologies do improve production, this only speeds up depletion.	New technologies and better information have greatly increased recovery and will continue to do so.	At least some reservoirs are refilled by natural upwelling from deep in the earth.

SOURCE: DELOITTE RESEARCH

GEO-POLITICS

will energy flow unimpeded?

Threats to Production and Delivery

Separate from the question of how many barrels or cubic feet of fossil fuels are in the ground is the matter of getting them out of the ground and delivered to market. The potential issues surrounding production and delivery are at least as important as those pertaining to reserves. A basic reality of the energy business is that most of the world's oil and gas reserves are found in just a few countries, and many of them are or could become politically volatile. Likewise, many existing and potential transport routes pass through areas vulnerable to attack and otherwise difficult to maintain and protect. The CSIS *Geopolitics of Energy Into the 21st Century* draft report states: "In the early decades of the 21st century, because burgeoning energy demand will be met largely by oil and gas and because sources for these fuels will be increasingly concentrated in a small number of suppliers, the risk posed by supply interruptions will be correspondingly greater than is presently the case".

EXHIBIT 9. THREATS TO ENERGY PRODUCTION AND DELIVERY

	EXPLORATION AND PRODUCTION	SHIPPING AND TRANSMISSION	REFINING AND PROCESSING	GENERATING AND DISTRIBUTION
OPEC HOLDBACKS				
CONFLICT, POLITICAL TURMOIL IN KEY PRODUCING AND TRANSIT AREAS				
SABOTAGE LINKED TO POLITICAL, SOCIAL, RELIGIOUS GRIEVANCES				

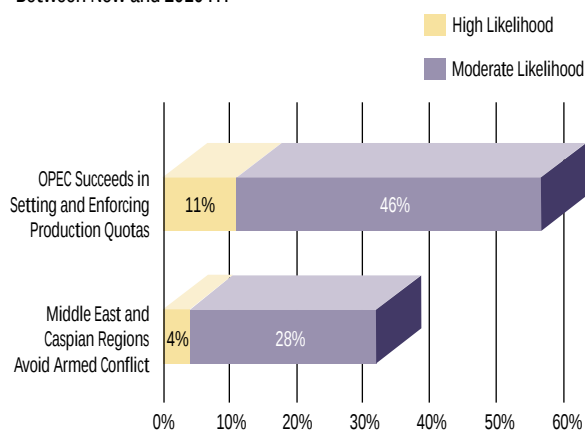
SOURCE: DELOITTE RESEARCH

Pertinent Survey and Interview Responses

The respondents to the Welling & Co. survey are relatively optimistic. They are dubious about OPEC's ability to make production cuts stick within the 2000-2010 timeframe. Nearly half – 46% – regard it as moderately likely that OPEC will be successful, but only 11% rate this as highly likely. Although only 4% believe it is highly likely the Middle East and Caspian regions will make it through the coming decade without armed conflict, it is evident they do not expect such conflicts to be serious – 78% believe the world economy will be generally strong throughout the decade, which would be unlikely if there were major disruptions in the flow of oil and gas. It can be inferred that the survey respondents are confident some combination of governmental conflict prevention, diplomacy, and military action will succeed in maintaining energy flows.

EXHIBIT 10. WELLING & CO. SURVEY RESPONSES RELEVANT TO SUPPLY RELIABILITY

Between Now and 2010 ...



SOURCE: DELOITTE RESEARCH/WELLING & CO. SURVEY

The relaxed attitude of the survey respondents is typical of those we interviewed in person. For example:

- The chairman, president, and CEO of a US utility stated that "I don't lie awake nights worrying about another oil embargo".
- When asked if he thinks political turmoil in the Middle East will seriously disrupt the flow of oil during the decade, a US investment banker responded, "No, not really. My gut instinct would tell me that some way, somehow, that oil will find its way into the market. If the economies keep ticking over as they seem to be in Europe for the next ten years, there will be demand for energy, so my guess is there will be some way that these fuels will find their way to market".
- An EC staff member said "it is important not to exaggerate the security of supply problem". He stated that by 2010 the EU will import 60% of their gas, mostly from Norway, Russia, and Algeria, but "none represents a strong risk with respect to interruption". He said Russian and Algerian producers "are hardly paid for their gas supplies in their domestic markets," so they "can ill afford to lose EU hard currency sales".
- An executive of an Australian utility doubted that terrorists will threaten energy infrastructure in that country because "we're too isolated and it would be hard to escape detection".

The following discussion examines a range of possibilities, opinions, and predictions having to do with potential production and delivery problems. Included are intentional production holdbacks, supply disruptions caused by trouble within or between producing and transit nations, and sabotage directed at energy infrastructure.

OPEC: Fearsome or Feeble?

OPEC's ability to keep oil off the market has become a key issue in light of the cuts the cartel initiated in March 1999. Much debate and speculation focuses on the question of how successful OPEC will be in controlling the flow of petroleum and keeping prices at the level they desire. One noteworthy development is that the frame of reference has undergone a change. As Robert Mabro of the Oxford Institute for Energy Studies says in a commentary posted on the OIES Website (<http://associnst.ox.ac.uk/energy/>):

The notional oil price that is now talked about as reflecting a reasonable, or 'comfortable', level is no longer the famous \$18 per barrel which ruled throughout 1987 to 1999, but \$25 per barrel. There has been a radical change in the mindset about prices... the market will continually assess price movements, and judge their deviations, by referring to this notional \$25 per barrel... We may have entered a new episode in the matter of oil prices: a \$ mid-twenty oil price which now supersedes the very long \$18 episode.

In August 2000 President Clinton all but officially ratified the new, higher reference price. In a press conference prior to his visit with the president of Nigeria he stated that "It needs to be, I think, in the low \$20s somewhere ... I think that the low to mid \$20s is the more sustainable rate".

During 2000 oil prices spent increasing amounts of time above the \$20 range. Even assuming energy-consuming nations would not be distressed if oil prices during the decade were in the "low to mid \$20s", it is not clear if this is a durable benchmark. As the following review shows, some believe oil prices will be considerably lower than that in coming years, while others see them staying there or higher.

OPTIMISTIC VIEW: OPEC WILL BE COOPERATIVE OR UNABLE TO ENFORCE CUTS

One possibility is that the OPEC producing nations will not keep oil prices high during the new decade. This assumes Colin Campbell and Jean Laherrere are wrong that prices will be forced up due to dwindling reserves. According to this scenario, OPEC will not stand in the way of making oil available, either because the members agree to keep their product affordable, or lack the discipline to

ration production, or cannot stop market forces from undoing any attempts to extract monopoly profits.

OPEC denies it means to hold prices at painful levels. OPEC spokespersons contend the cartel is simply trying to prevent price gyrations of the sort that caused prices to fall 30% in 1998. OPEC's Secretary-General stated in early 2000 that "We are not in the business of fixing prices ... we are in the business of stabilising prices". Later in the year, with prices above \$30 per barrel causing an uproar in both North America and Europe, the cartel established a target band of \$22-28 per barrel.

Saudi Arabia is often portrayed as a moderating influence within OPEC. For instance, Mordechai Abir, energy and geopolitical analyst with Hoenig Group, told the *Dallas Morning News* that Saudi Arabia, the UAE, and Kuwait have large reserves and want to keep the world dependent on oil. "The last thing they want to see is undermining industrial companies and emerging Asian economies, to undermine their continuous economic growth of the last few years", he said. "Their wish is to find a price that will be good for both producers and consumers, not in the teens, not \$12, \$15, \$17, which is insufficient for them, but in the mid \$20s".

At least in public Saudi Arabia has presented itself as striving to keep prices in the middle of the target band. For example, after OPEC's September 2000 meeting Saudi oil minister Ali Nuaimi insisted that, "We said before we intend to bring the price down and we will bring it down. We want the price at \$25 a barrel".



Venezuela's president Hugo Chavez has said his country supports the \$22-28 price range and the head of the national oil company PDVSA has issued assurances he will approve investments to increase production capacity if necessary to meet Venezuela's quotas. A member of the Council of the Americas told the *New York Post* Chavez reaffirmed his commitment to the target band in an address to the group during the Millennium Summit in September 2000: "The president has assured us. We expect the situation to stabilize".

However, it could be that market forces are more consequential than OPEC in determining how much oil flows at what prices. While prices may soar in the short run, in other words, the long-run result could be lower prices because any time the cartel raises prices non-OPEC competitors will step up production, countering the price escalation and stealing both revenues and market share.

Robert Priddle, IEA Executive Director, laid out this thesis at a December 1999 conference:

OPEC faces the paradox that if it reacts cohesively to a low price shock so as to convince the market that, this time, it really will be able to attain and hold its chosen price, it simply provides secure production headroom for non-OPEC producers who might otherwise have hesitated to invest in expanded production.

In agreement is Sheikh Ahmed Zaki Yamani, former Saudi oil minister and now chairman of the London-based Centre for Global Energy Studies (CGES). In a September 1999 address, he gave four reasons why OPEC's new campaign to raise oil prices manifests a

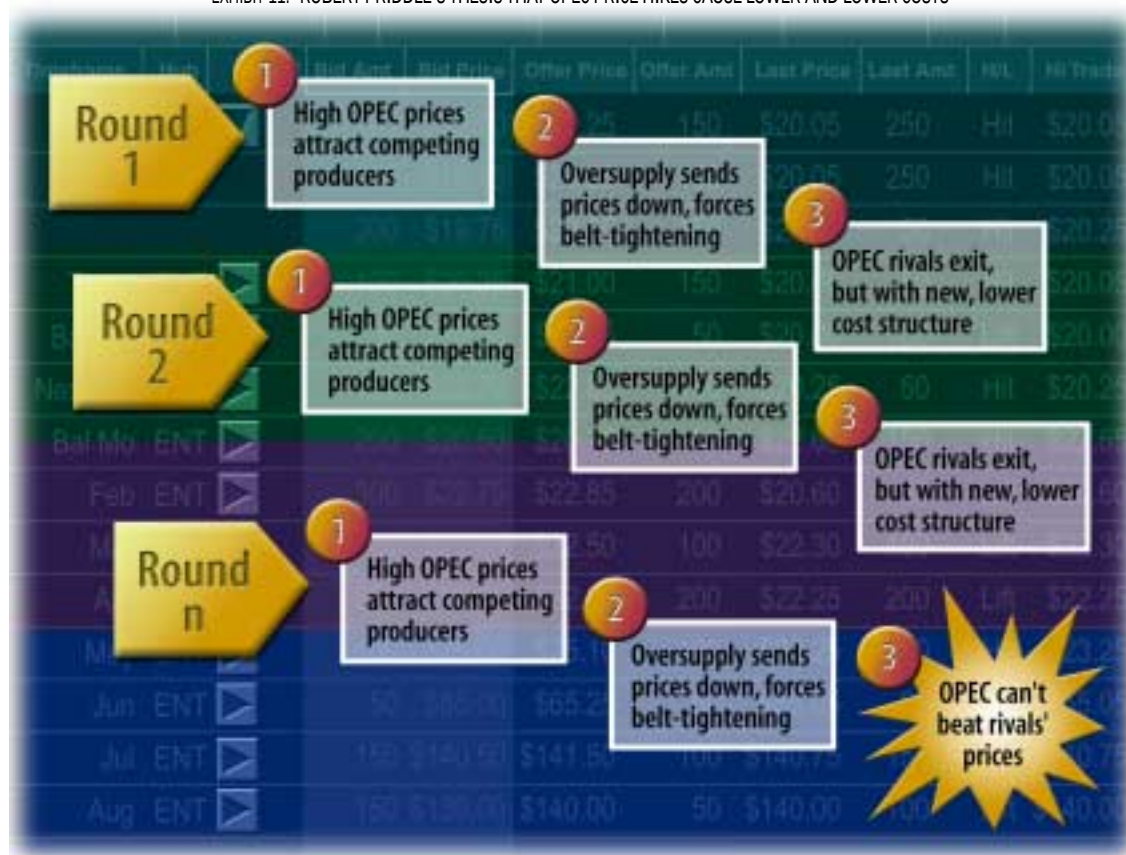
"misguided mindset". The difficulty of preventing quota cheating is one. Another is the price of maintaining idle capacity. A third is the demand-suppressing effects of higher prices. What he regards as most telling, however, is the likelihood that high prices would promote competition from other producers. Assuming OPEC was then trying to guide oil prices to a band in the upper teens or low 20s, Yamani opined that this was "too high a target". He argued that prices in that zone would "give the non-OPEC producers every incentive to explore for and develop new supplies", and pointed to activity in Canada, the US, and North Sea as evidence that the reaction was already building. "The sensitivity of non-OPEC oil supplies to changes in the oil price is significant", he said, "and history has shown that OPEC disregards this fact at its peril".

A year later Yamani was more dire. OPEC "will pay a heavy price for not acting in 1999 to control oil prices," he told Reuters. "I think prices might go a bit higher this winter but further ahead in 2001 prices will start to come down and longer term it is horrible for OPEC".

Fleshing out that prognostication, CGES in September 2000 warned OPEC that, once the northern hemisphere's winter demand eases, oil prices will fall, possibly getting below \$13 per barrel by late 2001. Only huge production cuts will prevent such low prices, according to CGES: "If OPEC really wants to keep prices close to \$25 per barrel it will need to make a dramatic cut in output in 2001".

Priddle argues that any OPEC attempts to raise prices will not simply produce reactions that return them to their previous levels, but rather will bring about ever more rigorous price competition. Exhibit 11 illustrates his thesis, which is that when OPEC price increases elicit new non-OPEC production and thus eventually a supply glut, the rest of the industry becomes leaner and tougher before prices reach the point where they must drop out of the game. When OPEC next raises prices the level at which non-OPEC production increases are triggered is lower than before. And after the returning competition sends prices down again, the point at which OPEC's rivals finally exit the market is lower as well. "I suggest that such interventions will inevitably lock us into a sequence of boom and bust cycles and into a long-term downward price trend," Priddle asserted in his December 1999 address.

EXHIBIT 11. ROBERT PRIDDLE'S THESIS THAT OPEC PRICE HIKES CAUSE LOWER AND LOWER COSTS



SOURCE: DELOITTE RESEARCH

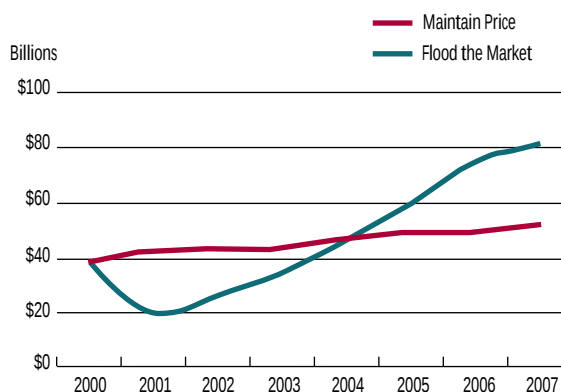
Luis Giusti, former PDVSA Chairman and CEO, says the price level at which non-OPEC producers can compete effectively was about \$25 per barrel in the late 1980s but is now around \$12-14 per barrel. Separately, J. Robinson West, chairman of the Petroleum Finance Co., says Saudi Arabia cannot survive on less than \$15 per barrel.

An entirely different scenario involving low oil prices comes from Nawaf Obaid, a Saudi who wrote *The Oil Kingdom at 100*³ while at the Washington Institute for Near East Policy. In essence he argues that Saudi Arabia would be better off if it worked with the market rather than against it. He recommends that the kingdom begin "producing at capacity – a 'flood the market' approach", inviting international oil companies to help it increase its production capacity to ensure market domination.

According to Obaid's figures, the resulting gush of oil would send prices down to \$5 a barrel in 2001. As illustrated in Exhibit 12, he predicts prices would gradually rise again as higher-cost

producers left the market. Seven years later, Saudi Arabia would be earning tens of billions more than if it adhered to the price-maintenance approach, Obaid reckons.

EXHIBIT 12. NAWAF OBAID'S ILLUSTRATION OF THE POSSIBLE REVENUE IMPLICATIONS OF A SAUDI "FLOOD THE MARKET" STRATEGY



SOURCE: NAWAF OBAID, *THE OIL KINGDOM AT 100*

Of course, the trick for Saudi Arabia would be to cope with the interim reduction in revenues. As Obaid concedes, "During the first five years ...when increased market share has not yet offset low prices, the Saudi economy would suffer from decreased oil revenues – almost \$50 billion in the third year". So how to make it through? Obaid thinks the answer is "to move forward with the long-planned divestiture of state enterprises". He estimates that the kingdom could earn \$85-111 billion by selling off the four main state enterprises, and by freeing up five years' worth of subsidies. Selling the three other state enterprises could bring in another \$30-40 billion, he contends.

Obaid notes that influential Saudis favour a market share increase strategy, including Prince Abdulaziz bin Salman, deputy oil minister. "As a possible future oil minister", Obaid says, "he can be expected to perpetuate the liberalizing economic policies of his predecessors or even to move them further toward free market ideas". He quotes a former Saudi cabinet minister as saying Prince Abdulaziz is "a strong candidate for having a larger say in formulating Saudi oil policy in the future, since his prestige and power will increase as he gains more experience".

But wouldn't a dominant Saudi Arabia exploit its position by forcing consuming nations to pay high prices? Obaid cites various reasons why this would not necessarily happen: the Saudis favouring the market share strategy are generally moderates with extensive foreign experience, Saudi policymakers are aware that high oil prices encourage the development of alternative fuels, and the Saudi view of an acceptable price level is \$17-20, well below the target band OPEC agreed to in 2000.

Thus there is the prospect of a situation in which Saudi Arabia would dominate the supply of oil but would keep prices down in an effort to stave off competition and substitute products. "One cannot rule out this possibility", Obaid argues, "because of the temptation for the Saudi leadership to eliminate the need to haggle with OPEC, drive high-cost producers from the market, and decimate alternative energy research with one swift action".

PESSIMISTIC VIEW: OPEC WILL KEEP OIL OFF THE MARKET

The possibility that 1970s-style oil production holdbacks could be made to stick was brought home to consuming nations when OPEC displayed unusual discipline in adhering to the production quotas it set in March 1999. That resulted in prices more than tripling over the next year or so. Arguably the 1999-2000 price rise shows the cartel can be unified for long periods when the right conditions prevail.

Members of OPEC could have several reasons to keep prices high on a sustained basis:

- **Revenues to fund government spending.** *The Economist* articulated this thesis when it characterised OPEC as a "manipulative bunch" whose "first loyalty will always be to the depleted exchequers of their often over-indebted and extravagant rulers". University of Vermont associate professor F. Gregory Gause III says in a *Foreign Affairs* article that "Saudi oil policy is now driven primarily by the immediate revenue needs of a government struggling to maintain a welfare state designed in the 1970s – when money seemed limitless".
- **Arab-Israeli tensions.** Some of the price rise in 2000 has been attributed to Arab concerns over American efforts to influence Israeli-Palestinian peace talks. *The Wall Street Journal* reported that industry officials and analysts believed: "The Saudis are signaling their displeasure at U.S. pressure on the Palestinians to give up some of their claims on Jerusalem by refusing to increase oil production". Even if the issues raised in the 2000 round of talks fade, other frictions and crises related to Arab-Israeli relations could periodically emerge to take their place.



■ **Anti-Western agenda.** Some see President Chavez of Venezuela as trying to use oil prices as a means for giving developing nations leverage with the industrialised world. *The Economist* says Chavez hopes that emerging as a leader of a strong OPEC "will turn him into a champion of the impoverished masses of the 'south'". The Dow Jones Energy Service says "The Venezuelan president sees OPEC as a tool to alter the world order... Chavez doesn't mind stepping on the toes of giants by championing engagement with internationally isolated nations such as Iraq, Iran and Libya". At the Caracas OPEC heads of state summit in September 2000, Chavez told his counterparts that "together we will be invincible". As for his announced support of the \$22-28 band, an oil company executive told the *New York Post* that "President Chavez is making a lot of noise, but he's been very resistant in telling the other OPEC members to increase production".

There is also the possibility that large oil producers could come up with new institutional structures that would strengthen their position. Nawaf Obaid notes that OPEC could admit countries such as Kazakhstan, Mexico, Norway, and Russia. Alternatively, OPEC could be replaced by a new cartel composed solely of the largest producers.

But what about the chronic disunity that has marked dealings among oil producers? As Canada's *Globe and Mail* has observed, "since the late 1970s, OPEC membership has become synonymous with quarrelling and cheating". But the paper cautions that, with Venezuela now a loyal team player, and with an apparent rapprochement between the more moderate Saudi Arabia and the more radical Iran, "consuming countries can no longer count on a weak and divided OPEC".



Politics in Key Energy Regions: Tranquillity or Turmoil?

National leaders in key energy regions sit atop unstable social and political systems. Not only their oil and gas fields but their pipeline routes and shipping lanes could be affected by coups, counter-coups, revolutions, protest demonstrations, and warfare. Possible trouble spots include the Middle East (site of 30% or more of the world's oil production, 34% of the world's natural gas reserves, and the Straits of Hormuz, Bab el-Mandab, and the Suez Canal), Russia and the rest of the former Soviet Union (site of 9% of the world's oil production, 39% of the world's natural gas reserves, and crucial pipeline routes to both Europe and Asia), the Straits of Malacca (bordered by major oil and gas producers Indonesia and Malaysia), and Venezuela (site of 5% of the world's oil production and one of the largest suppliers to the US).

OPTIMISTIC VIEW: PRODUCING AND TRANSIT NATIONS WILL BE POLITICALLY STABLE

One possibility is that between now and 2010 problems in these places could prove manageable. We found some evidence of reforms, improving conditions, and relaxing tensions. Champions of liberalisation and globalisation think those forces foster the kind of progress that pulls attention away from domestic and international grievances.

Middle East. Saudi Arabia, shaken by political and religious rifts in the 1990s, is said by some knowledgeable observers to be far more stable today. Optimistic accounts of the Kingdom's prospects cite developments such as improved relations with Iran, consideration of WTO membership, planning for privatisation, the removal of various impediments to foreign investment, and the Supreme Economic Council for promoting more participation in discussions of economic reforms. An analysis from the London-based International Institute for Strategic Studies (IISS) states that "the presence on the council of Prince Talal, an open advocate of democracy, suggests that the council could herald a genuine attempt at reform". The Kingdom has indicated interest in having

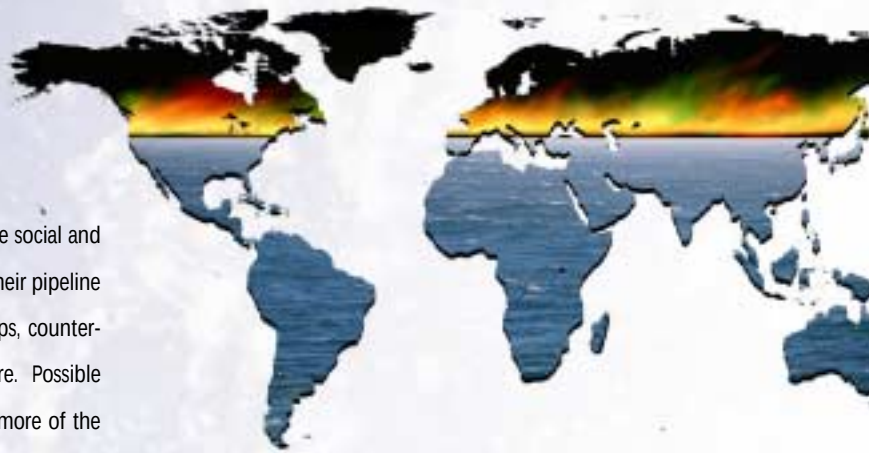
international oil companies participate in its oil and gas industry, although the specifics remain under discussion. Nawaf Obaid writes in *The Oil Kingdom at 100* that Saudi Arabia is moving its policymaking process "toward a more formal, professional, and bureaucratised system – one that more closely resembles the Western model of public administration".

With respect to Iran, the defeat of reactionary forces in the February 2000 parliamentary elections arguably marked a fundamental turn for the better. An IISS analysis says the voting "resulted in a landslide victory for those eager to reform Iran's government. Although hard-line conservatives waged a rearguard action, the elections have entrenched democracy, and even initiated a process of secularisation".

Efforts to alleviate transport bottlenecks between the Middle East and Asia could reduce tensions associated with the growing Asian reliance on the region. For example, the proposed Kra Canal project in Thailand is meant to provide an alternative to the congested Malaccan Strait sea lanes used to ship oil from the Middle East to Asia.

Although pessimists often worry about trouble as aging Middle East rulers die and succession issues confront political systems with little provision for power transfers, the initial signs are reassuring. Jordan, Morocco, and Syria have now anointed successors without incident.

Stratfor, the US business intelligence consultancy, predict that during the new decade the Middle East will be a "peaceful backwater". With the Cold War concluded, Stratfor believes, frictions within the region will have less global significance, and the



competing interests will have to do without the avid attention and financial backing of superpowers. Stratfor do not expect complete tranquillity. They anticipate trouble as Iran and others advocating the Islamic republican model of government exploit the fading strength of the old secular radical regimes in Egypt, Iraq, Libya, and Syria. They also foresee Islamic militants grasping for control during successions in the conservative monarchies, especially Saudi Arabia. However, their "Decade to Come" forecast is that the new political movements will be "fairly manageable" and the Middle East will maintain an "uneasy peace".

Russia. *The Economist* has noted that as of 2000 Russia's economy is growing, foreign-currency reserves are rising, inflation is under control, more taxes are being collected, the rouble is stable, and public finances are looking healthier. Whilst the communist candidate won 29% of the votes in the early-2000 presidential elections, the fact that elections were held and Vladimir Putin won can be seen as keeping the flame of democratic reform flickering. As for the many ills afflicting the Russian business sector, *The Economist* points out that 10 years ago Poland's chances of warming to democracy and capitalism were thought to be low, yet today it has one of the strongest economies in Eastern Europe.

An article appearing in the IISS publication *Survival* maintains that Russian nationalism is not the threat depicted by some Western commentators because many decades of government based on ideology have deadened nationalistic passions and stunted civil and social institutions capable of mobilising ethno-national mass movements. The IISS *Strategic Survey 1999/2000* concludes that "for the West, any worry about Putin's intentions will be tempered by his evident pragmatism and Russia's obvious economic and military weakness".

PESSIMISTIC VIEW: PRODUCING AND TRANSIT NATIONS WILL BE POLITICALLY VOLATILE

There are also disquieting scenarios, as some of those looking on the cheerier side acknowledge. Basically these focus on dire consequences if governments are unable to manage various problems that jeopardise domestic tranquillity and international relations. The impact of conflict in key areas where energy is

produced and transported could be grave. For example, the CSIS point out that two-thirds of Saudi Arabia's daily oil production comes together at the intersection of several pipelines.

Middle East. In their book *Oil Security*⁴, Brookings Institution scholars Edward Fried and Philip Trezise say that, despite many positive signs in the Middle East, "quasi-military threats, coups, or war cannot be ruled out, and for that reason neither can oil supply interruptions leading to another price shock".

The CSIS study sees oil-rich countries as experiencing increasingly serious demographic, economic, and political strains. The draft report says that "domestic turmoil within key energy producing countries constitutes another threat to reliability of energy supplies. At least 10 of 14 top oil-exporting countries run the risk of domestic instability in the near to mid-term".

Amy Meyers Jaffe of Rice University and Robert Manning of the Council on Foreign Relations write in *Foreign Affairs* magazine that Persian Gulf states face social unrest, leadership succession crises, demographic problems, falling per capita incomes, and growing national debts. They contend that low oil prices could push Middle Eastern countries to the breaking point. "Without healthy oil revenues to buy off restive populations," they assert, "the Gulf leaders will be left with only repression to silence foes and quell public discontent, which could fuel even more violent opposition".

Given the severity of the internal challenges facing Middle Eastern governments, some question whether even years of high oil prices would be sufficient to ensure tranquillity there. An IISS analysis notes that Saudi Arabia's Crown Prince Abdullah "has warned that although the oil price has tripled since early 1999, the Saudi budget cannot long sustain princely extravagance on its traditional level". But much more than high living by royals is at issue – the demographics of Saudi Arabia and other Middle Eastern countries arguably present grave threats to political stability.

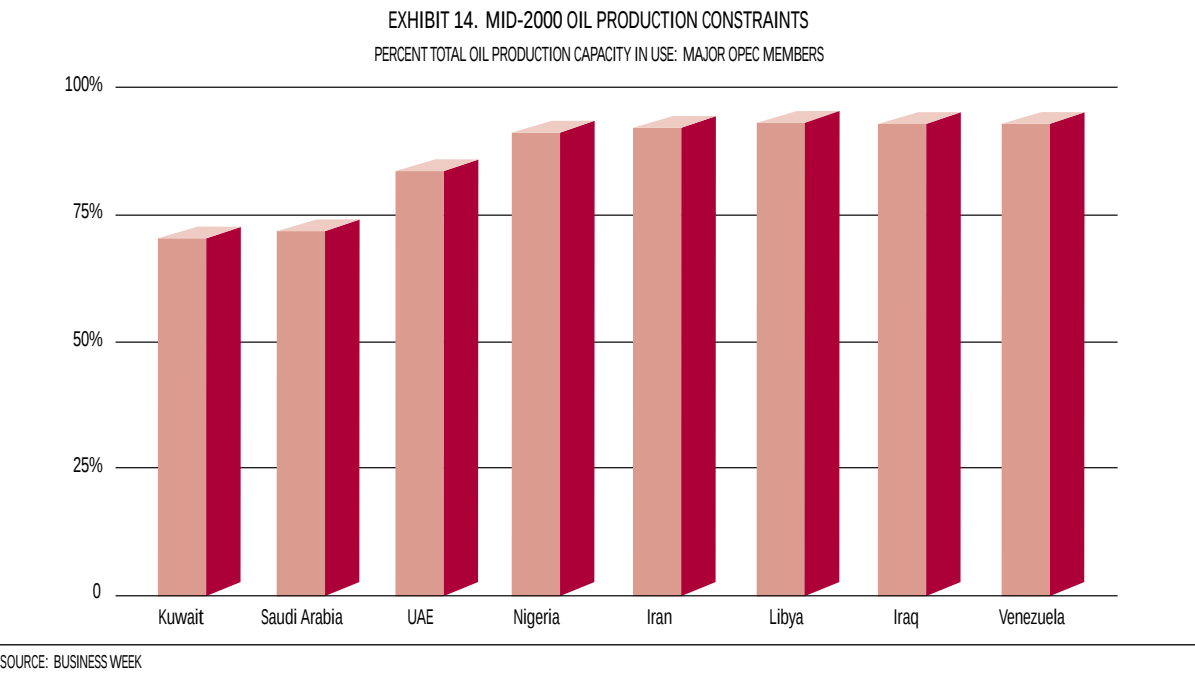
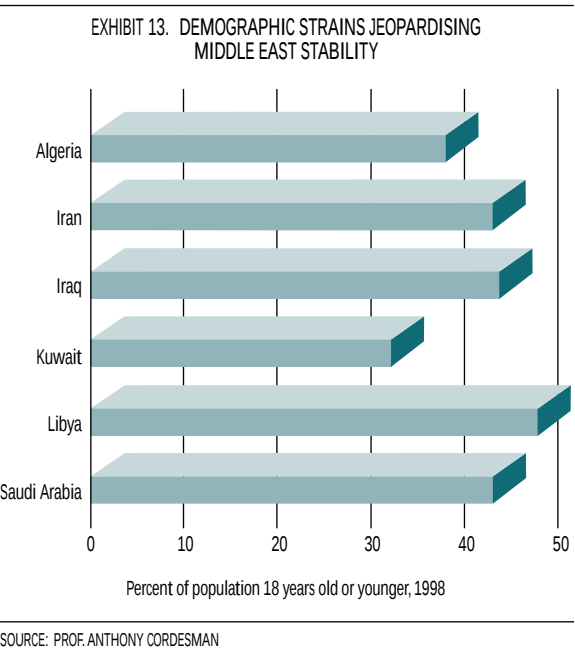
Prof. Anthony Cordesman of Georgetown University and the CSIS gave a 1999 address to the Eighth US Mideast Policymakers Conference in which he pointed out that the Middle East faces a "youth explosion" – about 40% of the region's population is now under 18 years of age. In order to meet the growing need for jobs, food, housing, and other necessities, governments will need to repair

and update their economic, educational, and political systems, he said. Prof. Cordesman contends the Middle East has long failed to reform oil-centred economies, encourage the private sector, or attract and make effective use of foreign investment. He faults the region's leaders for repeatedly announcing reforms but failing to deliver. "The problem does not lie in lack of the right policies or repetitive effort to begin reform, but rather in a lack of sustained follow-through", according to Cordesman.

Although increased oil revenues provide more resources for housing, education, medical care, and so on, extra money does not necessarily improve the odds Middle Eastern leaders will address the challenges inherent in the population statistics. In fact, Stanford University professor Terry Lynn Karl contends the reverse is true. In her book *The Paradox of Plenty*⁵ she argues that political leaders showered with oil dollars tend to hold power tightly, buy off political opponents, and invest in showy projects favoured by cronies. This promotes inflexible, centralised power structures and official complacency while underlying problems fester. In the *Journal of International Affairs*, she says:

Petro-states are seldom forced to adapt – and never on time. In this sense, petrodollars 'lock in' and reinforce previous oil-based development choices, producing institutional rigidity and high barriers to reform... As a result, change – when it finally does come – is provoked by profound political and economic crises.

Huge public and private investments are needed to refurbish and expand energy infrastructure throughout the Middle East, Russia, the Caucasus, and Asia. As the figures in Exhibit 14 show, capacity constraints were part of the reason for the jump in oil prices during 2000. Without major new investments oil and gas in the ground may stay there, or oil and gas en route to market may not make it.



However, political risk keeps capital away from many producing nations.

Dr. Walid Khadduri of the Egyptian online publication E-Petroleum (www.e-petroleum.com) points out the toll that political unrest has taken on gas pipeline projects in the Middle East:

This state of permanent crisis means, in effect, that the construction of pipelines across nation states is not considered a viable option in the long term because of the political risks involved. Moreover, even when projects are implemented during a period of cordial relations between two countries, as was the case with the gas pipelines between Iran and the former Soviet Union or Iraq and Kuwait, these projects become the first victims when the political situation deteriorates and relations sour between the parties concerned.

Big-power geo-politics are also a factor. Dr. Khadduri observes that "The US objects to the transit of gas pipelines from the former Soviet Union countries through Iran, or the construction of gas export pipelines from Iran to neighboring states. US pressure has also delayed the 8bn cu. M/year natural gas pipeline from Libya to Italy".

Warfare could also disrupt production and delivery. As the CSIS draft report states, "Military conflict will remain a threat to most energy-producing regions, particularly in the Middle East where two-thirds of the world's oil reserves are located". Recent hostilities in the Middle East illustrate the potential for trouble in the decade ahead.

Although some political leaders and commentators complain about the US role in the Middle East, others fret about a reduction in US involvement. One concern is that the US may be less available to keep the lid on the Middle East if it is increasingly able to meet its oil needs from Venezuela and other Atlantic basin suppliers. Jaffe and Manning say this could be especially problematical if China, Japan, and perhaps other Asian nations jostle to establish a presence in the region due to increasing reliance on Middle Eastern oil and gas. Fereidun Fesharaki of Honolulu's East-West Center concurs. In *The Journal of International Affairs* he writes that US interests in the Middle East have diminished since the Gulf War and "With U.S. dependence on Mideast oil falling rapidly... garnering American support will prove much more difficult in the future".

Should geopolitical tensions cause armed conflict, the consequences could be serious due to the ongoing build-up of weaponry. As the CSIS draft report says:

The likely proliferation not only of weapons of mass destruction (chemical, biological, and nuclear), but also of increasingly destructive conventional weapons (such as long-range missiles) means the fall-out from any inter-state conflict may be longer-lasting as well as more damaging in the short-term in terms of energy supply interruptions.



Iran's test-firing of a Shahab 3 intermediate-range missile in late 2000 is a case in point. Writing in the *Washington Post*, a former CIA Middle East specialist said the mission of the Shahab 3 is "unquestionably as a delivery vehicle for a nuclear warhead". He continued: "Backed by such weapons, Iran or Iraq could cajole, intimidate or even invade its neighbors, reasonably betting that Washington wouldn't eagerly play nuclear poker over oil wells".

Asia's growing need for Middle Eastern oil could provide new sources of arms. Dr. Fesharaki writes that "The new giant importers of oil – namely, China and India – will compete hard to forge special ties with the oil-exporting countries. In the process, they will likely make available weapons and technology".

Strife in the Middle East is not rare. Five major wars have erupted there in the past 30 years.

Central Asia and Caucasus. Writing about the Caspian Basin in *The Journal of International Affairs*, Dr. Martha Brill Olcott of the New York-based Carnegie Endowment for International Peace says "there is an increasing risk that the region's numerous social and economic problems will fester before adequate resources can be applied to remedy them". She goes on to discuss a list of problems that duplicates those in the Middle East – housing, education, health care, politics, and unemployment. The region is having its own "youth explosion" as well: "throughout the Caspian Basin region the workplace has to absorb tens of thousands of young people each year. This is virtually impossible in the current economic situation".

Jaffe and Manning believe the Caspian Basin will become explosive if oil prices plummet. In their *Foreign Affairs* article they say that, "socioeconomic woes threaten to destabilise almost all the governments of Central Asia and the Caucasus" and warn that "the complex problems of the Caspian region – evidenced by turmoil in Chechnya, Dagestan, and Kyrgyzstan – could, if left to fester without the salve of oil wealth, make the Balkans look like a pregame warm-up".

Russia. Russia's future is chancy, according to many experts. Internal turmoil there could affect gas supplies to European customers, and, depending upon what deals are made during the next few years, to customers in China, India, Japan, and elsewhere in Asia.

The same *Economist* article that cited the promising aspects of Russia's situation also runs through a long list of problems, including corruption, organised crime, bureaucracy, meagre wages, falling GDP, falling population, decaying infrastructure, remilitarisation, powerful oligarchs, defiant regional and local leaders, KGB figures around the president – all capped off by the prospect of scapegoating and pugnacious nationalism if reform goes awry.

Stratfor concurs that scapegoating and pugnacious nationalism are concerns. They propose that the Russian army's surprising dash to Pristina during the 1999 Kosovo conflict marked a takeover of the government by nationalists in the military and intelligence community, now confirmed by Vladimir Putin's election as president

(although he may be a transitional leader, in Stratfor's view). In the new decade Russia will decisively reject liberalisation and Westernisation, according to Stratfor. Domestically this will mean a "witchhunt" and "terror" which will crush any and all allegedly to blame for "selling Russia to the West". Meanwhile, Russia's foreign policy will become expansionist and anti-Western. "Moscow will spend most of the next generation simply trying to rebuild its empire to the borders of the former Soviet Union", say Stratfor. They foresee Russia assembling a coalition to limit American power. This could bring about a vast Eurasian alliance – "we foresee a serious attempt by the Russians to work with the Chinese, an attempt we think will be successful".

That is a scenario former US Secretary of State Zbigniew Brzezinski finds highly disturbing. In *The Grand Chessboard*⁶ he says, "Potentially, the most dangerous scenario would be a grand coalition of China, Russia, and perhaps Iran".

Venezuela. Stratfor predict Venezuela's reliability as an energy source during the new decade will be jeopardised by an "explosive and dangerous mixture" – namely the country's significance as (1) the largest supplier of oil to the US, (2) the most appealing new route for the export of US-bound drugs from Colombia, and (3) the site of a new leftist political experiment in which President Hugo Chavez is attempting to limit foreign influences, halt privatisation, and improve the lot of the poor whilst maintaining oil flows and access to world capital markets. Stratfor's "Decade to Come" forecast states that "Venezuela is a pressure cooker for all the forces roiling Latin America".



Sabotage of Energy Infrastructure: Hits or Misses?

Supply interruptions due to terrorist attacks and other acts of sabotage upon energy infrastructure have to be included in the list of possible developments during the new decade. Oil rigs, refineries, pipelines, towers, generating stations, and other such facilities are prime targets for sabotage. Key choke-points or nerve centres are especially enticing. To some extent this is a continuation of the discussion regarding possible political upheavals in oil producing regions, but the problem of sabotage reaches into consuming nations and includes possible perpetrators beyond groups based in the Middle East.

OPTIMISTIC VIEW: ANY TERRORIST ATTACKS WILL FAIL

The threat of sabotage is well recognised within the energy industry and among the governments involved. A variety of high-profile studies have been conducted to assess the risk and define countermeasures, one example being the US President's Commission on Critical Infrastructure Protection cited in Part 2. As a result, many believe terrorism, whilst a matter of concern, is under control.

Supporting this view is the fact that safeguards at all levels from the international to local provide multiple layers of protection. Especially with such defences in place, bringing off a successful attack on energy infrastructure requires a level of logistical capabilities that is thought to be beyond what most terrorist groups can muster.

New technologies that increase the ability of terrorists to escape detection and that put more powerful destructive capabilities within their grasp are worrisome but hardly make it certain these means will be used successfully. As a RAND expert testified before a 1999 Congressional hearing, a focus on low probability/higher-consequence threats "can degenerate into a fact-free scaffold of anxieties and arguments – dramatic, emotionally powerful, but analytically feeble".



In August 2000 the US Defense Secretary said he is aware of efforts by unnamed foreign countries to mount attacks on America's information infrastructure, and energy was one of the sectors he mentioned as being at risk: "If you ... could cause the collapse of our energy production and distribution system just by typing on a computer and causing those links to this globalization to break down, then you're able to wage successful warfare, and we have to be able to defend against that". However, he issued an assurance the US is well-protected: "We're taking these [preventive] measures".

Even if terrorism does increase, it is not clear energy infrastructure will bear the brunt, at least in consuming nations. Attacks upon refineries, power stations, gas lines, and so on could be highly disruptive, but there is evidence that the nature of the terrorist threat is going in a different direction. As stated by the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction in a late 1999 report to the US President and Congress, it appears there is a "portentous shift in terrorism, away from its traditional emphasis on discrete, selective attacks toward a mode of violence that is now aimed at inflicting indiscriminate and wanton slaughter". Thus shutting down a refinery or plunging a city into darkness may not be violent enough to meet the new terrorist criteria.

No paralysing sabotage of energy facilities has occurred either in the big countries of Europe, Asia, or North America, nor in producing and transit areas such as the Middle East and Russia, and this arguably reinforces the conclusion that supply disruptions due to sabotage are not very likely to be a major problem between now and 2010.

PESSIMISTIC VIEW: TERRORISTS WILL DAMAGE ENERGY INFRASTRUCTURE

Whilst no substantial stoppages of world energy flows have resulted from sabotage, this is not to say the record is totally clear. Terrorists have shut down oil and gas pipelines in Algeria, Colombia, and Chechnya. And in the developed world many attempts have been made and some successes have been achieved. Before the 2000 Olympics, Auckland police raiding an organized crime ring with links to Afghanistan found what appeared to be evidence of a plot to blow up a Sydney nuclear research reactor near the site of the Games. In 1996, London police raided an IRA hideout and stopped a plot to blow up energy and water installations. The police found 36 explosive devices six IRA agents planned to use against electrical substations, gas valves and pipelines, and water pumping stations. In the US, authorities have logged 1,000 attacks against energy infrastructure over the past 15 years, some involving outages and damage. At a Deloitte & Touche conference in late 1999 a representative of a major US transmission system described hacker attacks on the organisation's computer systems as a daily occurrence.

The growing use of standardised IT in energy sector operations makes cyber-terrorism more of a concern. A report by the US Electric Power Research Institute states that greater standardisation has the unfortunate potential of facilitating cyber-sabotage. The President's Commission on Critical Infrastructure Protection made this observation about US energy facilities and systems:

From the cyber perspective, supervisory control and data acquisition (SCADA) systems offer some of the most attractive targets to disgruntled insiders and saboteurs intent upon triggering a catastrophic event... With the exponential growth of information system networks that inter-connect the business, administrative, and operational systems, significant disruption would result if an intruder were able to access a SCADA system and modify the data used for operational decisions, or modify programs that control critical industry equipment or the data reported to control centers.

The intellectual and logistical difficulties that surround the job of bringing off a successful act of terrorism are among the factors

that explain the comparatively sparse record of truly serious attacks. However, the same advances in information and biological sciences that bring simplification and miniaturisation make sabotage easier as well.

As stated by the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction:

The difficulties now facing a terrorist who may seek to use a CBRN [chemical, biological, radiological, or nuclear] weapon to achieve mass effects could change dramatically because of new discoveries, further advances in technology, or other material factors.

Thus there is a case to be made for concern about possible sabotage of energy infrastructure both in producing and consuming nations. The record of near-misses shows that the threat is real, and technology developments create new vulnerabilities in the energy sector that some individuals or groups might be able to exploit.

Summary of Differing Assumptions About Reliability of Energy Flows

In this section we have examined a range of possibilities regarding the outlook for energy production and delivery in the period 2000-2010. We addressed disruptions from (1) production cutbacks imposed by producers, (2) violence stemming from political turmoil and military conflict within producing areas, and (3) sabotage by terrorists or other saboteurs.

The more supply is uninterrupted, the more conditions favour consuming nations and customers, except when supplies are so generous and prices are so low that the energy sector begins to buckle. The more production and delivery are restrained, the more conditions favour the energy sector, except when supplies are so low and prices are so high that customers rebel and new alternatives begin to appear – especially if the reductions are not intentional on the part of producers.



Our research found a variety of facts, opinions, and predictions supporting the proposition that there will be no serious energy supply problems during the new decade. These include the following:

- OPEC will honour its public commitments to keep oil prices within a band that consuming nations consider affordable.
- Even if OPEC tries to keep prices up, its efforts will fail because members of the cartel will cheat on their quotas, and new competition will develop in response to the high prices.
- Alternatively, Saudi Arabia will flood the market with oil and drive out the more aggressive OPEC members.
- Conditions in potential trouble spots such as the Middle East, the former Soviet Union, and Venezuela are more stable than before and this will prevent supply disruptions from political upheavals.
- Sabotage of energy infrastructure is unlikely because the logistics are so complex, and because of the layers of protection governments have established.



We also found support for much less auspicious scenarios. Disruptions of energy flows could materialise if events bear out the following assumptions:

- OPEC will be more united and more anti-Western.
- Middle East and Caspian Basin countries face exploding youth populations, and a variety of social and economic crises guarantee that these countries will be politically volatile even if oil revenues are high.
- Outside powers will increase their presence in the Middle East and thereby create new rivalries and conflicts while making more arms available.
- Russia will become more unstable and nationalistic, disrupting energy flows from the Caspian Basin as well as Russia itself.
- Venezuela will no longer be a reliable source because of its participation in OPEC cutbacks, or because of internal political turbulence.
- Terrorists will be able to avoid detection and launch more effective attacks thanks to new vulnerabilities linked to information technology.



Our findings demonstrate there are contradictory sets of beliefs about the outlook for energy production and supply between now and 2010. Exhibit 15 summarises conditions that would be conducive to a high degree of reliability during the decade. The more conditions diverge from those shown in the table, the greater the potential for disruption.

EXHIBIT 15. EXAMPLES OF CONDITIONS REQUIRED FOR HIGHLY RELIABLE ENERGY PRODUCTION AND DELIVERY, 2000-2010

CONDITIONS SUPPORTING HIGH LEVEL OF SUPPLY RELIABILITY

	NATURE/ENVIRONMENT (<i>natural resources, weather, climate</i>)	■ N.A. ■ No pattern of more frequent and stronger earthquakes, particularly in major urban centres such as Tokyo, Kobe, and San Francisco.
	SOCIETY/CULTURE (<i>associations, educational systems, social welfare agencies, religious institutions, families, individuals</i>)	■ People in energy producing and transit nations are patient and resilient in coping with problems in areas such as unemployment, housing, education, and health care. ■ People in the Middle East, Caspian Basin, and other areas with a history of ethnic and religious strife resist new conflicts. ■ Societies in the Middle East and elsewhere withhold aid and comfort from terrorists.
	SCIENCE/TECHNOLOGY (<i>laboratories, R&D centres, and standard-setting bodies operated by governments, nonprofits, companies</i>)	■ New technologies enhance governments' ability to control terrorists, and/or ■ No new technologies that increase terrorists' ability to elude authorities, and/or ■ No new technologies that magnify terrorists' destructive capabilities.
	ECONOMY/BUSINESS (<i>lenders, investors, rating agencies, exchanges, companies, trade associations, professional services firms, unions, executives, managers, workers</i>)	■ Key producing and transit nations experience satisfactory levels of economic growth while reducing their dependence upon energy revenues. ■ Capital markets provide funding needed to upgrade and expand production and transport facilities in places such as the Middle East, Caspian Basin, and Russia. ■ Energy industry and markets resolve any production and delivery disruptions without undue turmoil.
	POLITICS/GOVERNMENT (<i>administrations, agencies, commissions, courts, parliaments/legislatures, parties, and advocacy groups at the local, national, regional, and global levels</i>)	■ OPEC pricing policies are moderate, or exploitative efforts fail. ■ Governments in energy producing and transit nations address festering social and economic problems, avert unrest, and/or contain any unrest that develops. ■ Governments are adept at managing the international tensions associated with changing patterns of energy supply and demand. ■ Political support for terrorist groups and techniques declines or does not increase.

GLOBAL WARMING

*will fossil fuels
fall from favour?*

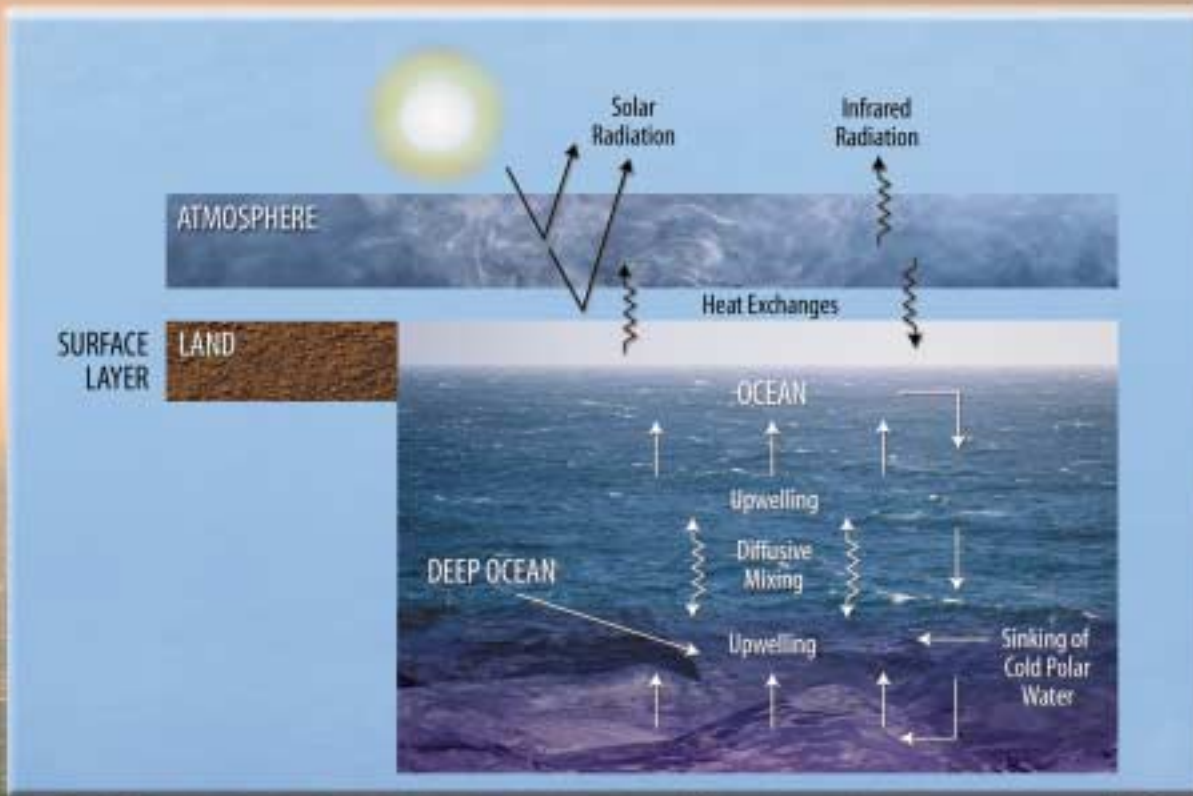
Energy and Climate Change

The production, delivery, and use of energy – particularly fossil fuels – entail environmental impacts of various kinds. Ecosystems can be disturbed, displaced, and destroyed by mining, drilling, and damming, and by large facilities such as refineries, generating stations, pipelines, transmission lines, and distribution networks. Air and water quality can be affected by pollutants from activities such as refining natural gas and generating electricity.

One of the most serious issues, however, is the possible effect of greenhouse gasses (GHGs) on the earth's climate. GHGs are CO₂, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and

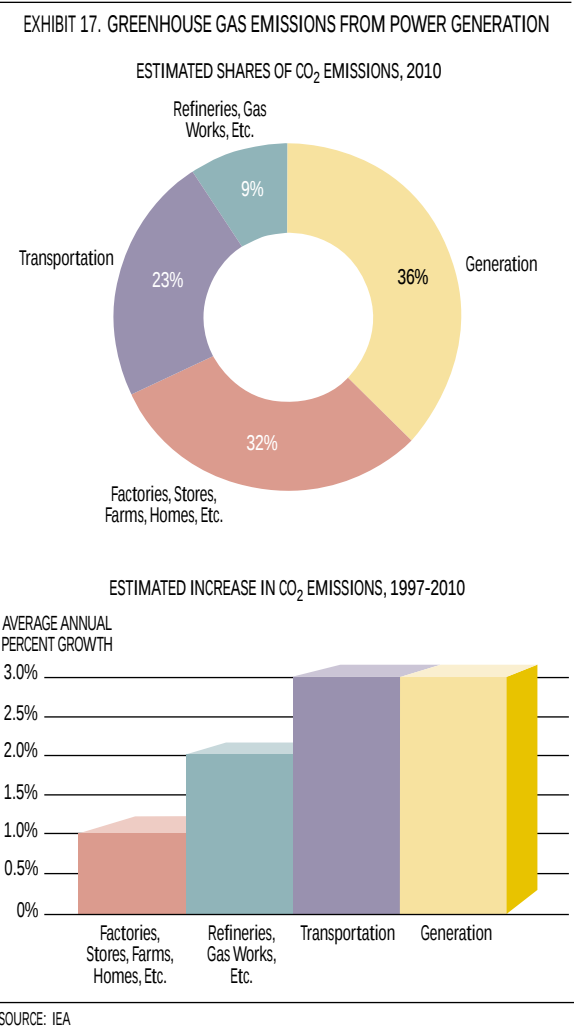
sulfur hexafluoride. Some scientists assert that atmospheric accumulations of GHGs from the combustion of fossil fuels are at least partly to blame for the phenomenon called "global warming". (We use "global warming" interchangeably with "climate change", consistent with general usage, even though the pattern at issue is not a uniform rise of temperatures across the whole planet; the effects are said to involve warming in certain places and at certain times but not others.) Exhibit 16 illustrates the components of the climate system that determines the earth's energy balance and hence the planet's average surface temperature.

EXHIBIT 16. THE EARTH'S CLIMATE SYSTEM



SOURCE: GLOBAL WARMING

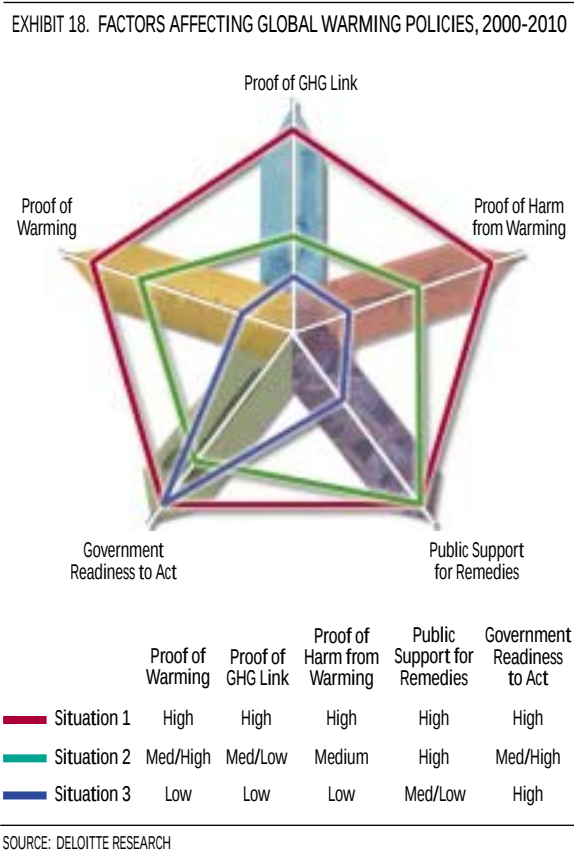
Global warming is a critical issue for the energy industry. As Exhibit 17 shows, electricity generation using fossil fuels is a major source of GHG emissions, and emissions from power plants are projected to grow steeply through 2010.



The Kyoto Protocol and related international agreements call for reductions in GHG emissions during the new decade. Exactly how this is going to play out is uncertain for a variety of reasons. Basically, there is continuing debate over the extent of global warming and about the role human activities play in causing it, if any. A parallel debate concerns the steps governments and private industry should take, if any, to restrict GHG emissions. The greatest opposition to mandatory emissions controls comes from the US. Opposition is also strong in Australia, Canada, and Japan. Europeans tend to be less resistant, although not all EU political and industry

leaders would accept controls if other industrial nations refuse to go along.

Exhibit 18 shows the variables that will influence how the global warming controversy impacts utilities between now and 2010.



One set of variables concerns scientific evidence about global warming, whilst the other concerns social attitudes about global warming and their political repercussions. As the new decade unfolds, events could lead to readings at almost any point along each of the five spectrums:

- One possibility is that there will be a neat correlation all the way around. That is, there will be the same degree of (1) scientific evidence on the question of how much warming is happening, (2) scientific evidence on the question of whether GHGs are responsible, (3) scientific evidence on the question of whether warming is harmful, (4) public support for action to reduce GHG emissions, and (5) governmental action to reduce GHG emissions.

- Other outcomes are possible, though. For example, there could be strong public and governmental pressure to do something about GHGs even without compelling new scientific evidence. Or there could be a contrast between the extent to which people favour action and the extent to which governments are inclined to impose stringent measures. Or there could be differences in how much progress occurs in pinning down the extent of global warming as compared to how much progress occurs in determining the extent of human complicity.
- Additionally, circumstances could vary from one country to the next – restrictions could be imposed in Europe but not Japan and North America. And there could be variation by time – one situation could prevail early in the decade and another could emerge by, say, 2008.

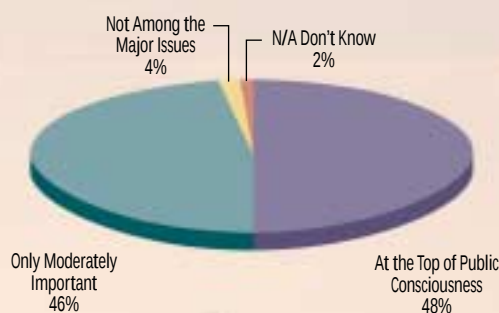
Hanging in the balance is the amount of effort and money utilities will expend to control their GHG emissions. At one end of the spectrum, utilities in many countries could find that adjustments they are already making, such as switching from coal to gas, will suffice to satisfy such pressure for emissions reduction as there may be. At the other end of the spectrum, utilities in many countries could be faced with edicts and/or taxes making a switch to different technologies advisable if not mandatory.



Pertinent Survey and Interview Responses

The Welling & Co. survey results were more divided on environmental issues than was the case in most other areas. As we note in Part 1, climate and weather ranked next to last in terms of their impact on the energy business in the 2000-2010 period. This certainly indicates the survey respondents see natural phenomena as playing a relatively minor role, at least compared to other factors. Yet conflicting signals emerged when we asked how important environmental issues will be in 2010. Forty six percent agreed with the statement that the environment will be only moderately important, and not among the top issues worldwide. But 48% agreed with a far more dramatic prediction – that the environment will be at the *very top* of public consciousness and among the *main* governmental policy issues worldwide.

EXHIBIT 19. WELLING & CO. SURVEY RESPONSES ON IMPORTANCE OF GLOBAL WARMING



SOURCE: DELOITTE RESEARCH/WELLING & CO. SURVEY

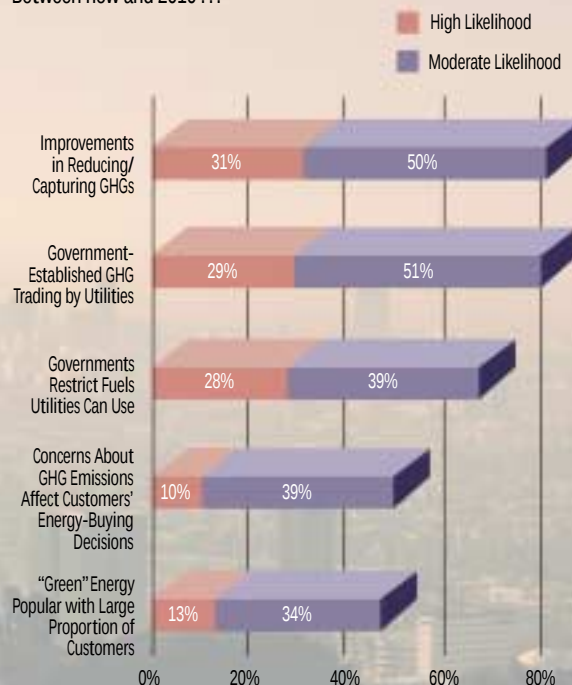
Other questions we posed on environmental issues produced responses that further suggest cross-currents in the group's thinking:

- Over 80% said it is moderately or highly likely that major improvements will have been made in reducing or capturing GHGs from industrial processes – half opted for moderately likely and nearly a third rated this highly likely.
- The response was similar when we asked about the possibility of government-sponsored systems for trading GHG emissions permits – a slight majority of 51% chose moderately likely, whilst 29% chose highly likely.

- A huge majority of 85% expects an increase in the use of natural gas as a fuel for generating electricity, and 52% expect an increase in the use of hydropower and other kinds of renewable energy for that purpose.
- A little over two-thirds expect government controls on what kinds of fuels utilities can use. Almost four in 10 see that as moderately likely, and 28% consider it highly likely.
- Fewer agreed with the proposition that customers' buying decisions will be affected by deep concerns about GHGs – 39% regarded it as moderately likely whilst only 10% regarded it as highly likely.
- A little under half expect that a large proportion of customers will want to purchase green energy even if it means paying a premium – about a third rate it as moderately likely whilst just 13% believe it is highly likely.

EXHIBIT 20. WELLING & CO. SURVEY RESPONSES RELEVANT TO GREEN ISSUES

Between now and 2010 ...



SOURCE: DELOITTE RESEARCH/WELLING & CO. SURVEY

Ways can be found to reconcile the responses. For example, they can be read as reflecting the expectation that climate worries will be intense during the decade, but that relatively modest efforts by governments and industry will be seen as keeping the situation under control. Further, the results can be seen as suggesting that many customers will be concerned enough about the issue to demand that governments and industry take action, yet most will be sufficiently satisfied with remedial efforts to resist the proposition that they need to pay more for green fuels.

Still, there is obviously some divergence of opinion within the sample. Our subsequent in-depth interviews with people inside and outside the industry revealed variation in outlooks as well.

First, there were different perceptions as to whether and to what extent global warming will be considered a problem:

- A member of the Bundestag told us, "There is now a 98% consensus that global warming is happening. In Germany and in Europe there is a consensus on this matter. Only a few well-paid outsiders argue against it right now".
- The energy manager for a European organisation said that, "by 2010, global warming and the greenhouse effect will be known for certain".
- The vice president of a US energy services company emphatically declared, "global warming is here – the only question is what to do about it".
- The managing director of an Australian utility expects support for environmental protection to grow: "The environment is firmly on our radar", he said. "I think that pressure is going to increase as you look at the younger generations becoming a lot more aware of the environment than the older generations. The pressure is only going to increase".
- A research fellow with a London institute doubts clear evidence will emerge within 10 years, but he thinks public opinion will shift nevertheless: "the consensus continues to move towards recognising that a problem exists".
- A UK equities analyst doubts there will be any clear decision either way on the science of climate change before 2010 and foresees inconclusive debate: "I don't expect to see any compelling evidence – I think the data will still be argued about".
- The chairman, president, and CEO of a US utility was more definite that nothing noteworthy will develop: "In the timeframe you're talking about, I don't think global climate change is going to dictate the price of electricity".
- The managing director of an Australian utility thinks climate change will be a non-issue long beyond 2010: "My view is that in the next 50 to 75 years, global warming will be imperceptible".
- The president of a US utility said he detects little concern about global warming in the state where his company operates, and observed that, with respect to the utility industry, "the majority of what's on the drawing boards right now is fossil fuels. There doesn't seem to be any concept that you have to plan for photovoltaics or some sort of green power".

Second, there was a spectrum of opinions on the extent to which meaningful action will be taken to do something about GHG emissions, and on the nature of such steps:

- The secretary-general of a European industry association sees global warming as receiving much more attention in Europe than in the US: "In Europe, I think there's a general conviction amongst the policy makers but also within the industry that issues of sustainable development, of curbing CO₂ emissions, are issues that will not go away, and that will remain very high on the political and societal agenda for the next 10 years and even for decades after that".
- An EC staff member predicted, "The economic impact of measures to deal with global warming will be equal to the oil embargo of the 70s".

- The research fellow with the London institute expects some emissions trading, and thinks some industrial countries will be forced to buy up emissions credits from the developing world as an alternative to taxing fuels.
- The chief executive of a New Zealand utility believes governments may act even without forceful new evidence of global warming: "Mandatory control measures are more certain than increasing scientific proof climate change is real".
- The head of an Australian utility doubts the effectiveness of voluntary efforts, because "until there's legislation on the amount of greenhouse gas emissions and following through on those commitments there will be a lot of rhetoric about it, but there may be little done".
- Not all executives oppose government intervention: An executive with an Australian gas company noted that "efforts to deal with global warming aren't entirely detrimental to our interests", not only because one of the results could be to promote gas, but also because doing nothing could mean taking drastic measures later and "it's no good to get a bigger piece of a smaller pie".
- Another EC staff member said "Receptivity to gas will get a boost from concerns about global warming and the Kyoto Protocol".
- The CEO of a US fuel cell manufacturer thinks global warming could favour distributed generation: "The fact that the fuel cell units emit 40-60% less carbon dioxide should be an attractive feature, but we can't depend on that to sell these products. That could change if global warming increases, which could produce an atmosphere that requires the use of environmentally-friendly devices".
- However, the senior VP of a US technology company was sceptical as to how serious many Americans are about reaching into their pocketbooks to help cut CO₂ emissions: "Customers may be concerned about global warming, and they may want to use environmentally safe energy, but if you tell them they'll have to pay extra for that, they'll say 'no'".

- The head of facilities management for a UK retailer complained about government revenue-raising schemes masquerading as CO₂ reduction measures: "I think we [business] should support Kyoto, but we want to actually devote our energy to something that works, not something that's an excuse for raising 1.75 billion pounds".
- A New Zealand civil servant was noncommittal about policy in his country: "The government accepts there's a problem. We're prepared to act if others do. But since so much of our power comes from hydro, generation is less of a carbon contributor here".
- An executive with an Italian utility agrees global warming is a major issue, but thinks government action will be less than decisive. He considers the Kyoto Protocol as "only a surface initiative", and predicts that by 2010, "The European Community will have issued a rule, but it will not be implemented by Italy yet".

The response to a question in the October 2000 survey of 600 US households conducted for us by ICR confirms the American resistance to incurring extra costs to fight global warming, at least for now. Only about a quarter said they would be very willing or somewhat willing to pay an extra 20% on their monthly electric bill to enable their utility to switch to cleaner fuel, while nearly half said they would be not at all willing or somewhat unwilling to pay such a charge.

Global warming and its implications are thus difficult subjects that elicit clashing views. In the following discussion we explore these topics in more detail, looking first at the question of how global warming will be perceived and then at the question of what may be done about it.



Natural v. Human Factors

One factor that complicates the global warming controversy is accounting for the role nature plays in altering the climate independent of any human influences – what scientists call “unforced natural variations”. An initial question is thus how nature will behave between now and 2010. If for reasons unrelated to GHGs nature serves up unusually harsh weather or other extraordinary natural phenomena, this could foster perceptions GHGs are affecting the climate beyond what is actually warranted – not to mention playing havoc with energy infrastructure. Conversely, natural phenomena could screen or suppress evidence of global warming, creating problems for scientists and others advocating GHG controls.

FIRST POSSIBILITY: NATURAL FLUCTUATIONS WILL NOT CAUSE PROBLEMS

It could be that between now and 2010 storms and natural disasters will remain within the realm of the ordinary. Some statistics lend credence to unexceptional scenarios. For example, the Australian Bureau of Meteorology reports that Australia's annual mean rainfall changed little during the 20th century and the number of tropical cyclones changed only in response to El Niño events. Global records show earthquakes in recent years have not approached the number or magnitude of the worst spell on record, which was in 1943. A USGS geophysicist stated in mid-2000 that, “Overall, earthquake activity isn't on the rise. We're simply able to locate more lower magnitude earthquakes due to advances in the technology”. Although some experts hold out the possibility of more storms, more temperature extremes, more earthquakes, and so on, the science involved is arguably not to the point where such warnings can be considered well-founded.

SECOND POSSIBILITY: SURPRISE DEVIATIONS WILL COMPLICATE ANALYSIS

It is also possible the decade will bring a new and unfamiliar level of intensity, in which disruptions are so serious and so frequent that they lend credence to global warming theories even if that is not scientifically justified.

Magnifying the impact of natural disasters is the increased concentration of populations and buildings in a relatively small number of urban areas, many of them in coastal areas or other locations vulnerable to damage. And the increasing number of participants in competitive energy markets means the task of maintaining and restoring networks is more complex than before.

There are some indications that nature could be more of a problem in coming years.

In his book *The Change in the Weather*⁷, New York Times science reporter William Stevens notes that the Holocene period – the geological and climatic epoch in which we live – has generally featured much worse weather than that to which humans today are accustomed. “The earth's climate over [the past 18,000 years] often has been harsher and more disruptive than anything experienced by anyone alive today” Stevens reports. And, he warns, “the forces at play in the not-so-distant past could come into play again”.

What sort of weather might suddenly return? Mega-droughts are one example. Stevens points out that “the Holocene is studded with droughts stretching for decades and even centuries”. And floods: “The last 10,000 years in North America have also seen frequent extremes of flooding, much of it surpassing anything seen in modern times. And extended cold: “a plunge to much colder temperatures than those of the Little Ice Age took place about 8,000 years ago in the North Atlantic region”.

Stevens quotes Professor Richard Alley of Pennsylvania State University as saying this temperature shift was “a big event, something that affected a huge chunk of the world, and it's a lot bigger than modern humans have ever experienced”. Alley says this indicates the Holocene might yet spring a surprise or two – “and we won't like it”. Dr. Alley has since written *The Two-Mile Time Machine*⁸, in which he discusses ice core data from Greenland and Antarctica indicating that big climate changes have happened in as little as a single year. He chairs a committee of scientists from the US, the UK, and Switzerland that is conducting a two-year study under the auspices of the US National Academy of Sciences entitled “Abrupt Climate Change: Implications for Science and Public Policy”.

Looking back thousands of years, Dr. Mary Bourke, a geomorphologist at the Washington-based Smithsonian Institution, says of cataclysmic floods, "my research indicates that these events can be bigger and more frequent than we have ever known in the Earth's current climate. According to *The Wall Street Journal*, her findings imply "major catastrophes unseen in our lifetimes that could occur in tomorrowland wouldn't be all that unusual from the perspective of geologic time".

Reinsurer Munich Re say the number of natural disasters in the 1990s is triple that of the 1960s. The UN has determined that weather-related catastrophes in 1998 cost more than the sum of all such events in the 1980s.

EXHIBIT 21 RECENT NATURAL DISASTERS

	EVENT	LOCATION	YEAR
	Record rains and floods killed over a dozen, caused extensive property damage and power outages	UK	2000
	Record drought cut hydropower production in lower South America, resulting in power rationing, high prices, and staff downsizing	ARGENTINA, BRAZIL, CHILE	1999-2000
	Storms with hurricane winds killed 91, toppled 360 million trees, blacked out 3.4 million homes, and caused \$12 billion in damages	FRANCE	1999
	7.6 magnitude Nanku County earthquake killed 2,400 and caused \$14 billion in damages	TAIWAN	1999
	7.4 magnitude Ankara earthquake killed 17,000, destroyed 20,000 buildings, and caused \$3-6.5 billion in damages	TURKEY	1999
	Ice storm killed 25, destroyed electric transmission towers, blacked out millions of homes, and caused almost \$2 billion in damages	CANADA	1998
	7.2 magnitude Kobe earthquake killed 6,400, destroyed 250,000 homes, and caused \$100 billion in damages	JAPAN	1995
	Flooding of upper Mississippi River killed 50 and caused \$20 billion in damages	US	1993
	Category 4 (of 5) Hurricane Andrew caused \$38 billion in damages to southern Florida	US	1992
	Magnetic storm collapsed the Quebec power system, blacking out 6 million customers	CANADA	1989

SOURCE: USGS, NEWS ACCOUNTS

Writing in *The Daily Telegraph*, columnist Philip Eden says studies of weather cycles indicate that a long-term warming trend will bring instances of extreme weather during the first decade of the 21st century. He looks for the British Isles to experience colder winters and says "the winter of 2007-8, give or take a year, might be the severest for a generation, with two months or more of snow and ice on the ground". One of the implications: "great stress on the power industry". The industry will need to make any repairs rapidly, since Eden also foresees hot summers, with temperatures "warmer than the warmest years of the 13th century". He expects a UK record temperature above 37.8° C (100° F) by around 2010.

*The Coming Global Superstorm*⁹ argues that a natural warming process is underway that within two decades could cause the collision of Arctic and tropical air masses that would unleash horrific tempests with hurricane-force sustained winds. One of the authors told the *Scottish Daily Record* that "Scotland would be plunged into Arctic conditions and I would foresee at least three-quarters of the population being forced to leave". Moreover, he said "the conditions I have described are coming together even more rapidly than I realised when I wrote the book".

Earthquakes are another worry. The USGS in late 1999 warned that there is a 70% chance (plus or minus 10%) of one or more big earthquakes – magnitude 6.7 or greater – striking the San Francisco Bay area before 2030. A noteworthy aspect of the updated appraisal was the mention that among the data on which it is based are the discovery of previously-undetected faults and the revision of some assumptions regarding the region's earthquake history. Along these lines, a USGS geophysicist writing in the British weekly *Nature* revealed that recent research indicates that major earthquakes produce a "stress effect" which makes adjacent faults more prone to fail. He thinks this phenomenon played a role in the twin quakes that struck Turkey in 1999, and could mean that the area around Kobe is in increased danger as a result of the 1995 quake there.

Thus science has been underestimating the likelihood of quakes and could be doing so still. There is also the chance that living memory or even written history does not provide an accurate

guide to future patterns. The USGS scientist in charge of the San Francisco Bay study warns Californians against shrugging off the prospect of temblors. "The reality is that the region has gone through a period of anomalously low earthquake activity this century", he told the Associated Press. "The infrastructure, the population, everything has developed during a time of lower earthquake activity and we see higher earthquake activity coming down the road".

Although the onset (or return) of extreme events could heighten concern about global warming, some might have the opposite effect. What now appears to have been a temporary cold spell in the 1970s produced widely-publicised predictions of a "new ice age". The 1991 eruption of Mt. Pinatubo in the Philippines created an atmospheric haze that reduced solar radiation reaching the earth by 3% and depressed the average global temperature for two years, which again cast doubt on assertions a warming trend was underway. Future El Niños and La Niñas could have a lulling effect in regions where they produce unusually mild weather conditions, even though their damaging effects elsewhere might stimulate concerns about climate change.

Studies of weather cycles indicate that a long-term warming trend will bring instances of extreme weather during the first decade of the 21st century.

— Philip Eden,
The Daily Telegraph

Greenhouse Gases: Guilty or Innocent?

The possibility that extraordinary but natural events might affect the perceptions of scientists, political leaders, and ordinary citizens hints at the complexity surrounding the global warming issue. With that as a backdrop, we now go on to address the likelihood that human-induced global warming will turn out to be something utilities and the rest of society should worry about. We distinguish three related but discrete areas of uncertainty – whether global warming is occurring, whether GHGs are a cause, and whether global warming is harmful. We then move from science to public opinion and examine the role it may play in shaping policy on fossil fuels.

We have organised our research findings around two possible outcomes, first that the next 10 years will bring a high level of concern about GHGs, and second that concern will be minimal. This is admittedly a simplification, but it provides a convenient way to delineate the range of possible conditions between now and 2010.

FIRST POSSIBILITY: GREENHOUSE GASES WILL BE CONVICTED

Our research shows there is abundant support for scenarios in which the new decade brings a global warming crisis. We found facts, opinions, and predictions indicating that climate change is happening, that GHGs are at fault, and that damage to nature and to humans is building. We also found support for the proposition that public opinion tends toward concern rather than complacency.

Evidence of global warming. Thermometer readings in recent years suggest that the weather is hotter than it used to be. Worldwide, the decade of the 1990s is said to have been the hottest on record and 1998 is said to have been the hottest year. In the UK, the temperatures recorded were warmer on average than in any decade since record-keeping started 340 years ago. In Chicago, six of the summers of the 1990s brought above-average temperatures, and the summer of 1995 was the second-hottest in 127 years of record-keeping. Iceland's summer of 2000 was its warmest in 30 years. Many scientists believe the earth is indeed getting warmer. Graeme Pearman, Chief of Atmospheric Research at Australia's Commonwealth Scientific and Industrial Research Organisation

(CSIRO), has written in the *Canberra Times* that, while the science of climate change is not perfect, "some aspects of global climate are well established", and "one of these is the magnitude of warming that has been experienced in the past century". He states emphatically that "the world today is warmer than it was 100 years ago". Analysis of ice cores taken from high-altitude glaciers shows a warming trend, according to an article in a late-2000 issue of *Science* magazine. Ellen Mosley-Thompson of Ohio State University, one of the authors, says the research proves "The last century has been warmer than the last nine centuries, while the last decade has been the warmest period of all". The head of the US National Science Foundation's earth sciences division believes "This is something that needs to be taken quite seriously by all the peoples of the world".

In 1995 the United Nations-sponsored Intergovernmental Panel on Climate Change (IPCC) reckoned that average surface temperature has risen by between 0.3 and 0.6° C in the past century and predicted a rise of between 1 and 3.5° C (about 1.8 and 6.3° F) by 2100. This they called "a rate of increase of global mean temperature... greater than that seen over the past 10,000 years". In their draft third assessment report, to be published in 2001, the IPCC raise the estimated temperature increase during the new century in the absence of remedial measures to between 1.5 and 6.1° C (about 2.7 and 11° F). A draft of the next IPCC assessment report to be published in 2001 says additional analysis shows the upper range of possible temperature increases is higher than projected in 1995.

Reaching consensus on the question of temperature trends has been complicated by discrepancies between ground-level readings and readings in the lower troposphere which may or may not be due to flaws in the data. Global warming models have predicted that increases in surface temperatures would be matched by increases in the lower atmosphere. The credibility of global warming theory was called into question when measurements from satellites and weather balloons found either cooling or only small increases in the troposphere.

A January 2000 report by the National Research Council of the US National Academy of Sciences found that, whilst the satellite readings are accurate, the inconsistency is insignificant. The chairman of the panel that wrote the report said, "The differences between the surface and upper-air trends in no way invalidates the conclusion that the Earth's temperature is rising". The panel concluded that surface temperatures are the most meaningful indicator of warming and therefore the increases shown in surface measurements should be taken as definitive.

Moreover, the panel determined that the trend is sharply upwards – the report says surface temperatures in the past 20 years have risen at a rate much greater than average for the past 100 years. However, the panel acknowledged problems with data reliability and called for a better climate monitoring system to minimise errors and irregularities.

The Argo project could provide improved data. Its goal is to enhance understanding of ocean temperatures and currents using 3,000 floating sensors that alternately sink and then rise to beam data to satellites. The probes are being deployed by Australia, Canada, China, France, Germany, India, Japan, Spain, the UK, and the US.

Meanwhile, various changes in weather patterns have been cited as evidence of climate change. For example, a study of rainfall in Britain by scientists at the University of East Anglia (UEA) and the Hadley Centre for Climate Prediction and Research found that, over the past 20 years, individual winter storms have been dumping more rain than before. The harder downpours are significant – "climate models predict that global warming will be accompanied by an increase in the intensity of rainfall over the UK, particularly in winter", UEA's Dr. Mike Hulme told the *Daily Telegraph*.

Greenpeace claim melting of the Arctic ice cap corroborates warming theory. They say Arctic ice thickness has declined by more than 40% in the past 40 years, causing the disappearance each year of an area bigger than the Netherlands. German scientists claim wave heights in the Norwegian Sea have been increasing in recent decades according to a pattern that seems to track with rising surface temperatures. *Newsweek* magazine report that some scientists believe warming is responsible for the appearance of

Magellanic penguins near Rio de Janeiro, 2,000 miles north of their usual haunts – the theory is that warming has shifted the circulation of South Atlantic ocean currents which carry food the penguins follow.

GHGs and their role in global warming. The idea that GHGs are implicated in global warming picked up momentum during the 1980s. In 1988 National Aeronautics and Space Administration (NASA) climatologist Dr. James Hansen testified at a US Senate committee hearing that with "a high degree of confidence" he could say GHGs were causing global warming and making droughts and heat waves more frequent. He told the *New York Times* "It's time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here and is affecting our climate now". Coming as they did during a spell of record heat, drought, and forest fires, those statements from a government scientist created a sensation. The IPCC was formed later in 1988 due to the Hansen testimony and growing concern around the world.

IPCC's first report, issued in 1990, was clear on the connection between GHGs and long-term climate change. It stated: "We are certain... emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases... These increases will enhance the greenhouse effect, resulting on average in an additional warming of the earth's surface". The IPCC's 1995 report stated that "the balance of evidence suggests a discernible human influence on global climate". The draft 2001 assessment report says that since 1995 "stronger evidence" of human complicity has emerged, and that it is likely GHGs already "have contributed substantially to the observed warming over the last 50 years".

A key question about the coming years is whether evidence will surface that is so compelling it forces even the diehard global warming sceptics to concede its persuasiveness. As Washington policy analyst Michael Mazarr states in his book *Global Trends 2005*¹⁰, "If new studies prove once and for all that human-induced warming is under way, the call for public policy responses would become intense".

However, establishing a GHG link to climate change became somewhat more complicated when Dr. Hansen published a report in 2000 saying CO₂ has not been a significant contributor to global warming after all. The eventual consequences of this development are difficult to predict. Some see it as hurting the case against GHGs, while others believe it will promote acceptance of warming theory and the Kyoto Protocol.

The report in question appeared in the *Proceedings of the National Academy of Sciences* as an article entitled "Global Warming in the 21st Century: An Alternative Scenario". In it Dr. Hansen and four colleagues say their new analysis shows that the burning of fossil fuels has been a wash so far as warming is concerned – although CO₂ emissions trap a certain amount of heat that would otherwise radiate into space, small particles or aerosols also released into the atmosphere offset this by stopping about the same amount of the sun's heat from reaching the earth's surface. So according to their new research, carbon is not the villain, at least so far. "We assert the processes producing the non-CO₂ GHGs have been the primary drive for climate change in the past century" the authors say. They point the finger at methane and to a lesser extent chlorofluorocarbons. Those gases are arguably easier to control than CO₂, and are already the target of air pollution countermeasures.

This new theory does not necessarily mean CO₂ emissions are harmless. Although Dr. Hansen and his colleagues say the future trend in aerosols from fossil fuel combustion is uncertain, "the approximate global balancing of aerosols and CO₂ forcings in the past cannot continue indefinitely". If aerosol emissions decline, there will be less and less of the haze Dr. Hansen and his colleagues claim counters carbon's warming effects. Their article says "This interpretation does not alter the desirability of limiting CO₂ emissions" and "achieving the level of emissions needed to slow climate change significantly is likely to require policies that encourage technological developments to accelerate energy efficiency and decarbonization trends".

Thus it is possible to read the report as leaving intact the condemnation of CO₂ as an agent of global warming, but simply

saying that other GHGs have been responsible for warming to date because carbon's impact has been temporarily offset by small particles that could disappear. This is the view of Dr. John Holdren, Harvard professor of environmental science and public policy, who in a *New York Times* interview warned against concluding that remedies aimed at GHGs other than CO₂ will suffice: "This is not an either-or problem, it's a both-and problem. We're going to need all the cuts we can get".

Of course, there is no set level of evidence that must be produced before strong countermeasures win broad international support. To some extent political leaders and other shapers of public opinion can affect how much is thought to be enough. Al Gore is an example of a public official who argues that action on global warming is essential even if conclusive scientific confirmation of global warming theory is lacking. In his book *Earth in the Balance*¹¹, he endorses further research, but declares:

Research in lieu of action is unconscionable. Those who argue that we should do nothing until we have completed a lot more research are trying to shift the burden of proof even as the crisis deepens. This point is crucial: a choice to 'do nothing' in response to the mounting evidence is actually a choice to continue and even accelerate the reckless environmental destruction that is creating the catastrophe at hand.

The more that argument resonates in the US and elsewhere, the lower the bar will move in terms of how much scientific certainty will be required to justify GHG restrictions.

Effects of global warming. Pessimists believe rising temperatures will have detrimental effects. The IPCC project a range of problems: reduced biodiversity; major changes in the composition of an average one-third of forested areas; altered growing seasons and boundary shifts between grasslands, forests, and shrublands; an increase in desert temperatures and in desertification; the disappearance of one-third to one-half of existing glacier mass, with accompanying changes to snow and ice cover and river flow; changes in lake and river productivity, with increases in flow variability and alterations in wetlands distribution; greater coastal erosion and flooding, with altered tidal ranges in rivers and bays; and changes in ocean behaviour and sea-ice cover,

with major impacts on marine ecosystems and heat and carbon storage capacity. Exhibit 22 shows how rising sea levels could take a toll worldwide.

EXHIBIT 22. POTENTIAL EFFECTS OF SEA LEVEL RISE



SOURCE: FRIENDS OF THE EARTH INTERNATIONAL

A draft of the IPCC's third assessment report leaked to the BBC contains scenarios for various levels of CO₂ emissions. The scenarios with the highest levels imply widespread environmental horrors. One is the mass death of forests, with the trees releasing their stored carbon and thus adding to global warming rather than limiting it. Another is the collapse of the Ross Ice Shelf in Antarctica, leading to a global sea-level rise that would inundate densely-populated coastal areas.

The area between Tokyo and Osaka is thought to be vulnerable because land there is below sea level. Japan's National Institute for Environmental Studies have calculated that a one metre rise could displace 15 million people.

Global Warming and Terrestrial Biodiversity Decline, a report published in August 2000 by the London office of the World Wide Fund for Nature, contends that a doubling of CO₂ levels over the

next century could fundamentally alter a third of the world's plant and animal habitats and kill off 20% of the species in the Arctic and mountainous regions. Among the areas hardest hit would be Canada, Scandinavia, Russia, the US, and southeast Australia. The report depicts a world in which polar bears, Australian pygmy possums, and pine forests struggle while crabgrass, rats, and cockroaches thrive.

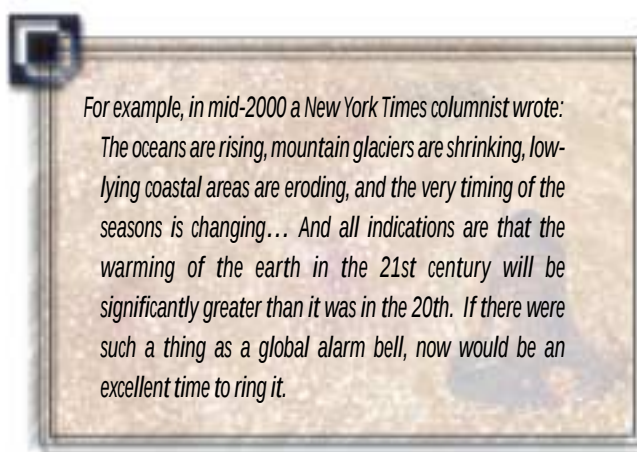
A UEA report issued in late 2000 found that global warming could benefit countries in northern Europe but would punish countries in the south such as Italy, Greece, Portugal, and Spain. The report, *Assessment of the Potential Effects and Adaptations for Climate Change in Europe*, said southern Europe could experience increased desertification, water shortages, forest fires, and air pollution. UEA Prof. Martin Parry told the *Financial Times* this could lead to mass migrations from the south unless the EU supported rural incomes.

The International Federation of Red Cross and Red Crescent Societies fear that if warming-induced rains and floods hit societies increasingly bunched in huge cities and hillside shanty towns, the results will be "a new scale of catastrophe". The Federation declare: "The explosive combination of human-driven climate change and rapidly changing socio-economic conditions will set off chain reactions of devastation leading to super-disasters".

In a *Times of London* article, writer and reporter Celia Brayfield notes the possibility that global warming could cause earthquakes and volcanic eruptions. The connection: rising sea levels could "destabilise fault lines and volcanoes". A particularly dramatic scenario of that type involves the volcano that constitutes the southernmost of the Canary Islands. Scientists fear a huge slab on the island's unstable west side could be jarred loose when renewed volcanic activity heats the water that permeates the underlying rock formations. The resulting splash would send a "mega-tsunami" crashing into US cities from Boston to Miami. Simon Day, a scientist from the Benfield Greig Hazard Research Centre at University College, London, told *Business Insurance* that rising sea levels attributable to global warming "could be adding to the pressure and hastening the date of the collapse".

Although assigning monetary values to the impact of global warming is extremely difficult and politically contentious, the IPCC in its 1995 report concluded that, using as a reference point a doubling of CO₂ concentrations, "best-guess central estimates of global damage, including non-market impacts, are in the order of 1.5-2.0% of world GNP".

Public opinion on global warming. Major media outlets around the world regularly feature news and opinion pieces indicating that global warming is real, harmful, and attributable at least in part to GHGs, even in the US.



One barometer of public opinion on global warming cited by environmentalists is the growing support for the annual Earth Day event, which celebrated its 30th anniversary in April 2000 (with clean energy as the theme). The Earth Day Network (online at www.earthday.net) claimed that the latest festivities attracted "hundreds of millions" of people to thousands of events in 183 countries.

Many public opinion polls show strong support for environmental protection in general and GHG controls in particular. An early-1999 poll of over 450 US opinion leaders by Mellman Group Wirthlin Worldwide for the Pew Center on Global Climate Change found that 61% believe global warming is happening now and 75% support emission reductions in line with those required by the Kyoto Protocol. A late 1999-early 2000 Roper Starch Worldwide survey of consumers in 29 countries found that the environment was ranked the number 1 concern by more respondents than any other issue.

Also pertinent is the public's perception of how scientists feel about global warming. Belief in global warming theory is often portrayed as the mainstream view within the scientific community. Scientists who question global warming are called "contrarians" by reporter William Stevens in his book *The Change in the Weather*, and he suggests "there may be something of a generational divide, with older scientists tending to be more resistant". "Heretics" is the term British technology writer Jonathan Margolis uses in *A Brief History of Tomorrow*¹², and he says there are "really very few".

Petitions and surveys demonstrate that many scientists support global warming theory. Prior to the 1997 Kyoto Climate Summit, the Union of Concerned Scientists circulated a World Scientists' Call for Action demanding remedies for global warming that garnered 1,500 signatures. A 1998 worldwide survey of scientists by the European Commission and the French education and environmental ministries found that the respondents considered climate change the greatest danger to the environment, ahead of population growth, water shortages, and pollution.

Soundings such as these are having an effect in the business sector. The Roper Starch executive heading the worldwide consumer study said, "the fact the environment ranks clearly number 1 on the list does send an important message to businesses everywhere". Many companies have already taken highly-publicised voluntary GHG-reduction actions, including BP, Dupont, IBM, Johnson & Johnson, Royal Dutch/Shell Group, Texaco, and Sun Oil.

Also suggesting support for GHG reduction is the shrinking corporate membership of the US-based lobbying group Global Climate Coalition (GCC), which opposes government restraints on fossil fuel use. BP left in 1997, Royal Dutch/Shell in 1998, Ford Motor Company in 1999. Then in the early months of 2000 three defections were announced: Texaco, General Motors, and Southern Company. At that point GCC chose to reorganise so that trade associations would belong rather than individual companies. *The Economist* calls the GCC a "spent force" and says it has been "eclipsed" by the Pew Center on Global Climate Change.

The Pew Center has organised a Business Environmental Leadership Council on which serve executives from AEP, BP, Enron, Entergy, Intercontinental Energy, PG&E, Shell, and Sunoco. The council's official statement says the member executives "accept the views of most scientists that enough is known about the science and environmental impacts of climate change for us to take action to address its consequences".

Such developments lead some observers to predict industry will accept meaningful action on GHG abatement. In *The Kyoto Protocol*¹³, three analysts from the London-based Royal Institute of International Affairs (RIIA) note that 10 years ago "the idea of significantly limiting greenhouse gas emissions would have been opposed by almost all the major industries on the planet". They contend that "the corporate world has changed", and they think key industries are likely to support or at least not wholeheartedly oppose adoption of GHG controls:

Many insurance companies, particularly global reinsurance, have become worried by cumulative and correlated weather-related losses. Natural gas companies have recognized that climate change probably holds as much opportunity as threat, whilst electricity and auto companies may envisage only modest transitional problems, providing that action is well-planned and not too hasty.

The RIIA analysts contend that if oil and coal companies and their primary industrial customers resist remedial measures they will be out of step with the majority of the corporate community. As early as 1998 the president of the National Environmental Trust told the *Guardian* that many oil companies "accept there will be a control regime and would rather get inside the tent to help shape it rather than staying outside, and eventually having to accept something they have not been able to influence". And in early 1999 a World Energy Council (WEC) staff official addressing a London meeting of the World Coal Institute said that "it has already been demonstrated that association with a hard-line approach leads to exclusion from policymaking fora".

Environmental groups could help firm up support for the pessimistic view on global warming. The *National Journal* in Washington, D.C. reported in September 2000 that such groups

were having an increasing impact on the US election campaigns of 2000. The article noted that the Sierra Club was spending nearly \$1 million to help pro-environment Congressional candidates and another \$8 million on voter education programmes in 24 Congressional districts. The League of Conservation Voters was said to be spending \$13.4 million to elect pro-environmental candidates. Both groups endorsed Al Gore for president.

In the Gore-Bush contest of 2000 there was a widespread presumption that a Gore victory was the outcome more likely to foster concern about global warming in the US. Although there was undoubtedly some validity to that belief (Bush officially opposed the Kyoto Protocol), it serves as an example of why care must nevertheless be taken in linking election results to future policy trends. Harvard economist Robert Stavins points out that key environmental initiatives have originated during Republican administrations – Richard Nixon signed the Clean Air Act and the Clean Water Act and set up the Environmental Protection Agency, and the Clean Air Act was renewed under George Bush. In the September 2000 *Atlantic Monthly* contributing editor Gregg Easterbrook suggested that George W. Bush as president might back government action on global warming because "taking steps that would be unpopular with Texas oil interests would lend his Administration an air of integrity".

SECOND POSSIBILITY: GREENHOUSE GASES WILL BE ACQUITTED

We also identified support for scenarios in which global warming theory fails to gain acceptance. We found facts, opinions, and predictions indicating that the case for climate change is shaky, that natural forces rather than GHGs are responsible for whatever changes may be occurring, and that the effects of any global warming that may occur will be negligible if not beneficial. And we found support for the view that public opinion is far from united behind global warming theory.

Evidence of global warming. Concern about rising average temperatures is not universal. Some reputable sceptics question whether the earth's atmosphere is getting hotter or, if it is, whether the amount of the increase provides cause for anxiety.

For example, Dr. Fred Singer, professor emeritus of environmental science at the University of Virginia, first director of the US Weather Satellite Service, former Environmental Protection Agency official, and president of the Washington-based Science and Environmental Policy Project (SEPP), believes average temperatures are not creeping upward. He testified before a US Senate committee hearing in mid-2000 that, "Contrary to the conventional wisdom and the predictions of computer models, the Earth's climate has not warmed appreciably in the past two decades, and probably not since about 1940". Singer maintains that surface readings indicating warming are trumped by what he contends is contrary evidence from satellites, weather balloons, tree rings, corals, and ice cores.

At the November 2000 Kyoto Protocol meeting in The Hague, Dr. Singer and six fellow sceptics from the US, Germany, and the Netherlands questioned the scientific basis for claiming the earth is warming, and argued there has been no increase in severe weather events such as hurricanes in North America and gale-force winds in Europe.

Dr. Roy Spencer, Senior Scientist for Climate Studies at NASA's Marshall Space Flight Center, thinks there are significant weaknesses in the measurements, computer models, and theories underlying many assessments of temperature trends. For example, in *Earth Report 2000*⁴⁴ he argues that "the rate of temperature change associated with daily weather is about 100,000 times greater than the widely-predicted 0.35° per decade global warming signal". He suggests that, given such minute gradients, readings of past and current temperature trends could be affected by factors such as changes in the instruments used for measuring, the movement of measurement sites from one place to another, the construction of buildings and other structures adjacent to thermometer sites, and the materials used in buckets used to draw ocean water for measurement. He doubts that clarifying the issues will confirm climate change alarms: "I believe that any warming will likely be more modest and benign than had originally been feared".

Others who question global warming theory foresee increases that at most reach the low end of the range projected by the IPCC and others. Dr. Robert Balling, a climatologist at Arizona State University, forecasts an increase of less than 1° F (about 0.5° C) over the next 50 years. SEPP's Dr. Singer predicts a warming of less than 1° F by 2100.

Some experts even foresee *falling* temperatures. Dr. William Gray, an atmospheric scientist at Colorado State University, expects warming to end over the next several decades, followed by a cooling trend.

One recent study found both warming *and* cooling. Headed by Dr. John Christy, associate professor of atmospheric science at the Earth System Laboratory of the University of Alabama at Huntsville (and a member of the IPCC), the 20-year study found that surface temperatures in portions of the Northern Hemisphere showed an up-tick in 1998 after no change for the prior 19 years, at the same time oceans in the Southern Hemisphere were experiencing long-term cooling. However, Dr. Christy attributed the rise in northern latitudes to the El Niño heating event and cautioned against assigning excess importance to such short-term events.

Sceptics dismiss some of the certainty that weather is getting worse as manifesting the human propensity to magnify recent events. The *Financial Times* quotes an analyst at the Benfield Greig Hazard Research Centre at University College, London, as saying "peoples' memories tend to be short. They feel that weather extremes tend to be on the increase". Reinsurance company Swiss Re states that, "scientifically speaking, there is as yet no indication of a significant long-term change in the frequency of events which can be ascribed to climatic change" (although the company does recommend cautionary steps).

Meanwhile, warming sceptics argue that a mark cut into a rock face on an island near Port Arthur, Tasmania, shows the IPCC is wrong when it says oceans are rising. The line was put there in 1841 by the Antarctic explorer Captain Sir James Clark Ross and amateur meteorologist Thomas Lempriere to mark what they believed was the mean sea level, and today it is about 30 centimetres above the current mean sea level.

GHGs and their role in global warming. Assuming the planet is heating up to an extent worth bothering about, the question remains as to why. Sceptics argue that, at a minimum, climate change pessimists should admit the link between GHGs and global warming is unproven. As evidence they point to findings such as those in a report by a panel of climate experts published in "The Bulletin of the American Meteorological Society" in December 1999, which concluded that the "greenhouse signal" cannot now be separated from natural climate fluctuations.

Likewise, although the National Research Council panel's January 2000 report determined that surface temperature increases should be accepted as showing a definite upward trend, this does not prove GHGs are causing global warming. The panel's chairman acknowledged that the finding "is not necessarily representative of how the atmosphere is responding to carbon dioxide and other greenhouse gases".

Professor Richard Lindzen, Alfred P. Sloan Professor of Meteorology at the Massachusetts Institute of Technology (MIT), is generally dubious about the theory that GHGs are causing temperatures to rise. He has written in *Regulation* magazine that, "as a scientist, I can find no substantive basis for the global warming scenarios being popularly described". He is particularly dismissive of environmentalist books by Vice President Gore and other political figures: "Rarely has such meagre science provoked such an outpouring of popularisation by individuals who do not understand the subject in the first place".

NASA's Dr. Spencer is likewise unpersuaded. In *Earth Report 2000*, he argues that natural forces may interact in ways that will offset any warming effects induced by GHGs. He also contends that neither computers nor climate theories are yet capable of taking into account all the factors bearing upon climate dynamics. He concludes that: "There remain substantial uncertainties in our understanding of how the climate system will respond to increasing concentrations of carbon dioxide and other greenhouse gases".

When the article appeared in which Dr. James Hansen modified his earlier explanations as to how GHGs impact the earth's climate, sceptics seized upon this as confirmation that the relationship between the greenhouse effect and global warming is not well

established. For example, a columnist in Canada's *National Post* wrote that, "as Mr. Hansen demonstrates, the science of global warming is still a very uncertain thing". In a similar vein, a *Detroit News* editorial stated, "if his research proves anything, it is that scientists do not know the answers to the most basic questions about global climate change".

More questions about the role of CO₂ have been raised by evidence that in the past global cooling has occurred when CO₂ levels were high. A study headed by Prof. Jan Veizer of the University of Ottawa and Ruhr University found that during an ice age 400 million years ago CO₂ in the atmosphere was about 15 times current concentrations. "The policy implications are huge", according to University of Pennsylvania geologist Dr. Lee Kump, who commented on the study in the British science journal *Nature*. "If large changes in atmospheric CO₂ in the past have not produced the climate response we thought they had, that undermines the case for reducing fossil-fuel emissions". Prof. Veizer believes the sun may be a bigger factor in climate change.

An experiment that could resolve at least some basic questions might occur early in the decade at a Geneva particle physics laboratory. Over 50 scientists have petitioned CERN to conduct an experiment to test a theory originated by Henrik Svensmark of the Danish Space Research Institute. The theory is that a strengthening of the sun's magnetic field is responsible for global warming because it has deflected cosmic rays which, if they reached the earth's atmosphere, would cause the formation of thick, low-level clouds that cool the surface. Says the petition: "If the link between cosmic rays and clouds is confirmed, the consequent global warming could be comparable to that presently attributed to greenhouse gases from the burning of fossil fuels".

Effects of global warming. Some scientists doubt the world will suffer even if warming does occur. The Cato Institute, a Washington-based libertarian think tank, has published *Satanic Gases*¹⁵, which seeks to refute dire portrayals of global warming's consequences.

The authors, climatologists Patrick Michaels and Robert Balling, say their review of 1,000 articles from peer-reviewed scientific publications leads them to conclude:

The exaggerated threat of global warming and glib projections of climate catastrophe are nothing more than political theater. As the planet warms, winters become less severe, growing seasons become longer, more food than ever is produced as the planet becomes greener and maximum hurricane winds decline. Rainfall is increasing while drought is not. There is no reason to expect that these salutary changes will suddenly reverse.

A study of 121 years of temperature data from the Rothamsted Experimental Station near Harpenden in southeast England by researchers from Arizona State University found that recent warming is part of a regular cycle and is non-threatening. The researchers' report states that "plants at Rothamsted... are now enjoying the many biological benefits associated with atmospheric carbon dioxide levels increasing from 300 ppm to 360 ppm... from the perspective of the plants and crops at Rothamsted, the subtle changes in climate must seem more like a blessing than a threat".

Public opinion on global warming. Although many opinion surveys show popular support for environmental protection, other evidence raises questions about how much genuine concern really lies behind some of the numbers.

For example, some surveys indicate people rate other issues higher than the environment. A Gallup poll taken prior to Earth Day 2000 found that Americans are more worried about topics such as education, health care, crime, and the economy than about the environment. Gallup's poll co-ordinator said it's a "second-level issue". Also, some surveys show that, among environmental issues, global warming ranks lower than others. A survey by the US activist

group Environmental Defense found that Americans are more worried about air and water pollution than about more complex issues such as global warming. Likewise, an Earth Day 2000 *Newsweek* poll found that only 12% of the respondents see global warming as their most urgent environmental concern, behind air pollution (19%) and ozone depletion (13%).

Phil Shabecoff, former *New York Times* reporter and author of two books on environmentalism, told the *Seattle Times* that "support for the environment and environmentalism is a mile wide and an inch deep". Some holding this view argue the crowds at Earth Day events mean less than meets the eye. Mark Dowie, a journalist and historian who is also the author of a book on the US environmental movement, told the *Seattle Times* that "Earth Day has become increasingly co-opted, increasingly saccharine... it's not a serious statement of a credible social movement".

With regard to the scientific community's influence on public opinion, Dr. Singer of SEPP insists "The number of scientists expressing scepticism on the global warming issue continues to grow, despite efforts to marginalize them". He notes that 17,000 US scientists signed a 1997 petition to reject the Kyoto Protocol. Prof. Lindzen of MIT belittles the significance of the petition circulated by the Union of Concerned Scientists on the grounds that only a handful of those who signed are climatologists.

Some argue the signs of greater environmental awareness among corporations are mainly attributable to public relations posturing. For instance, certain activists complain when corporations use occasions such as Earth Day to call attention to their achievements, which the activists see as "greenwashing" their poor environmental records. Josh Knauer, founder of the www.envirolink.org Website, told the *Washington Post* he sneers at "seeing some of the greatest polluters in the world gathering to celebrate Earth Day". Two activists associated with Corporate Watch said in a column published in the *South China Morning Post* that "beneath their carefully crafted, superficial green images, most polluting corporations go on with business as usual".

As for the exodus from the Global Climate Coalition, a Scripps Howard News Service story says these may be "less a result of a change of heart on the climate issue and more a reflection of the

desire of some companies to make themselves a smaller target for global warming protesters". The Coalition claim that none of the companies deserting their ranks has renounced the group's anti-Kyoto agenda.

Cynics consequently doubt industry will achieve truly significant emission reductions, or will be in the forefront of the struggle to win political support for the Kyoto Protocol or other remedial measures.

Beyond the possibility that public support for global warming theory is exaggerated lies the prospect that developments will occur that move it in the other direction. An example of a development with that potential is the change in Dr. James Hansen's analysis of carbon's role in causing global warming.

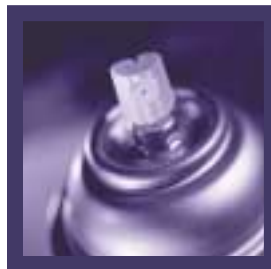
Hansen and his colleagues say it is likely that controlling the climate impacts of CO₂ emissions will require an acceleration of energy efficiency and of the shift away from fossil fuels in power generation, but they also note that CO₂ emissions are thought to have declined in 1998 and 1999. If a downward trend continued, it would take more pressure off fossil fuels and could be seen as meaning the problem is well under control.

Dr. Robert Watson, chairman of the UN climate change panel, told the *New York Times* that in the days after the Hansen article appeared he received a "flurry of phone calls from other scientists expressing worries that Dr. Hansen's study could be misportrayed". Recalled Dr. Watson, "They said this could easily be interpreted as the guy who got Vice President Gore all excited about global warming now saying everything's fine". Indeed, Dr. Hansen was quoted in the same article saying "The prospects for having a modest climate impact instead of a disastrous one are quite good, I think".

Whether environmental groups will succeed in promoting public acceptance of global warming theory, especially in the US, is yet another matter on which perceptions differ. As we note in Part 2, one staff member of a US activist group told us he is privately discouraged about the clout of organisations such as his. The same *National Journal* article that reported on the upswing in 2000 campaign spending by two prominent environmental groups also quoted the chief lobbyist for the US Chamber of Commerce as minimising the impact of even the millions of dollars in their treasuries given the overall magnitude of campaign expenditures: "It will be hard for their issue advocacy ads to break through the clutter".

British technology writer Jonathan Margolis provides one way of summarising the scepticism about global warming theory that motivates the "contrarians" and "heretics". In *A Brief History of Tomorrow* he observes that "we are being asked to believe that for the first time in the history of systematic thought about the future, humanity has got something entirely and uncompromisingly right". He then recalls past alarms that in his view proved unwarranted:

To rummage through the environmental panics of just the past few decades and come upon a golden oldie such as acid rain ... or desertification or fluoridation, DDT or aerosol sprays, is oddly reassuring, like finding, abandoned and unwanted in the attic, that old Pink Floyd album we once thought we could never do without.



Emission Controls: Mandatory or Voluntary?

In this section we examine the different scenarios that might unfold assuming some combination of scientific proof and public opinion create circumstances in which bold remedial action is called for. We divide the possible responses into two broad groupings: regulatory and voluntary. Under each heading we examine key prerequisites, first those having to do with cost-benefit implications and second those having to do with feasibility of implementation.

REGULATORY V. VOLUNTARY SOLUTIONS

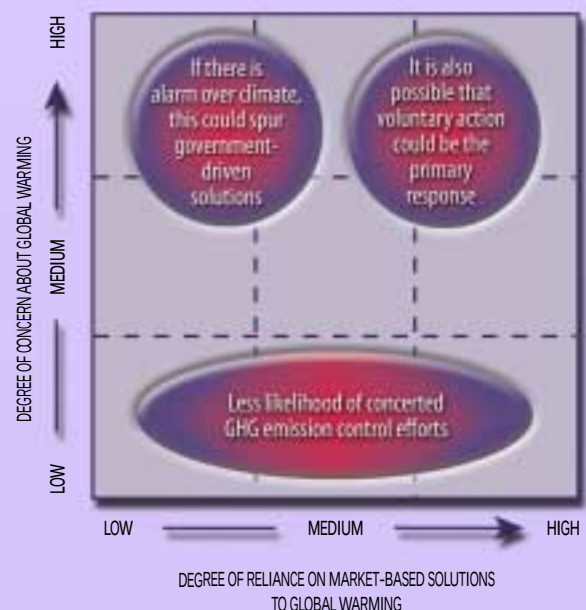
Proposed solutions to global warming are numerous and varied. Here we split them into two broad categories: (1) a regulatory or compulsory approach in which government plays a major role in defining both ends and means, employing policy tools such as national energy policies, emissions limits, emissions permit charges, carbon taxes, and mandatory reductions in the use of fossil fuels, as well as financial incentives and research funding; and (2) a market-driven voluntary approach in which companies and individuals determine for themselves what steps they will take, such as voluntarily cutting emissions or voluntarily trading emission allowances.

As a generalisation, global warming pessimists tend to favour regulatory solutions (optimists accuse them of pursuing an anti-free enterprise agenda), and global warming optimists tend to favour voluntary solutions (pessimists accuse them of counting on such schemes to minimise real GHG reductions). However, the possible scenarios are not restricted to circumstances in which a high degree of concern translates into more compulsory solutions and vice versa. Even today some who believe global warming is a genuine threat favour voluntary solutions (the main examples being corporate executives who agree GHG emissions should be cut but who oppose government mandates, as well as politicians concerned about the potential backlash from compulsory restrictions).

It is therefore possible that environmentalists will persuade the world GHGs are endangering the planet but free-market champions will succeed in getting voluntary reductions and trading installed as the chief remedies. Alternatively, stringent measures could be approved even if there were a relaxation of concern about warming, for example if a consensus developed that GHGs other than CO₂ would be the focus.

Where does the Kyoto Protocol fit within this framework? It could be part of either a mandatory or voluntary scenario. In a regulatory environment, the treaty would likely be interpreted more strictly, with an emphasis upon reducing GHG emissions from existing power plants and cars. In a more liberal environment, the treaty could still gain acceptance if greater reliance were placed

EXHIBIT 23. POSSIBLE OUTCOMES REGARDING SOLUTIONS FOR DEALING WITH GHG EMISSIONS



SOURCE: DELOITTE RESEARCH

upon market-oriented mechanisms such as permit trading. The treaty's prospects are also affected by the degree to which international co-operation enjoys favour – the more politics and economics are "global", the better its chances. (For a discussion of liberalisation and globalisation between now and 2010, see Part 2.)

FIRST POSSIBILITY: GOVERNMENT MANDATES WILL FORCE NEEDED ACTION

Scenarios in which government plays a major role in determining what is to be done about global warming are not difficult to formulate. The key components are a perception that corporate profits can be maintained while reducing GHG emissions, and a faith in the ability of government planners to properly define remedial measures.

Perspective on economic impacts. An impediment to scenarios involving the regulatory approach is the impression in some quarters that reducing GHG emissions entails so much risk to industrial nations' economic growth that only market-based, voluntary steps are appropriate. Were that view to fade, the regulatory approach would become more viable. A number of studies are said to substantiate the argument that GHG reductions can be achieved without hobbling economic growth, and these could form the basis for a growing confidence that mandates are safe.

Back in 1995 the IPCC determined that cutting GHG emissions would not be economically ruinous. The group of scientists and other experts agreed that "significant reductions in net greenhouse gas emissions are possible and can be economically feasible".

An August 2000 report to the Swiss government by the Advisory Body for Climate Change in Bern found that "reducing greenhouse gas emissions not only mitigates the global climate problem, it also entails substantial secondary benefits at the national level". Citing potential gains such as more technological innovation, less dependence upon energy imports, and cleaner air, the panel concluded that "the expected secondary benefits represent a key argument for a rapid implementation of effective measures to reduce greenhouse gas emissions".

Economists Robert Repetto and Duncan Austin report in *The Costs of Climate Protection*¹⁶ that a review of cost models led them to conclude that a properly-designed carbon tax "is a cost-effective way of reducing the risks of climate change and would do no damage to the economy". Also, a report published by the World

Wide Fund for Nature argues that the US would experience a net gain of almost 900,000 jobs by 2010 if it pursued a course of cutting carbon emissions by moving to energy-saving industrial and transportation technologies.

Data released in July 1999 by the Washington-based Worldwatch Institute indicate that carbon reductions and economic growth can happen simultaneously. According to Worldwatch, CO₂ emissions held steady over the prior two years as the global economy grew at 6.8%. This combination produced "an impressive 6.4% decrease in the amount of carbon emissions required to produce \$1,000 of income". Worldwatch attribute the reduction to improved energy efficiencies and falling coal use spurred by new energy efficiency standards and the removal of energy subsidies.

Eban Goodstein, an associate professor of economics at Lewis & Clark College and research associate with the Washington-based Economic Policy Institute, thinks this is representative of what private enterprise can accomplish within a set of government-prescribed constraints: "Given a specific target – produce commodity x emitting y percent less carbon – I have little doubt that US business firms will figure out how to do it at less than half the cost that economists think possible today". In *The Trade-Off Myth*¹⁷ he goes on to argue that US jobs lost due to GHG controls are likely to number in the thousands annually, and, "weighed against industry-sponsored, macromodel estimates of job losses in the millions, this layoff prediction may seem impossibly small".

A similar viewpoint has been articulated by Sir John Houghton, in his book *Global Warming*¹⁸. Houghton, former Chief Executive of the UK Meteorological Office, co-chairs the science working group of the IPCC, and chairs the UK Royal Commission on Environmental Pollution. He contends that action on the scale needed to mitigate climate change requires "significant policy initiatives by government" but he believes smart companies can do well within a government-prescribed framework:

The emerging technologies associated with energy efficiency in all its aspects, renewable energy production, and the efficient use and recycling of materials should bring increased employment in industry at a high level of skill and technical training. Because of increasing public awareness of the environment and of the need for its preservation, the industries which are likely to grow and flourish next century are those which have taken environmental considerations firmly on board.

Writing in the *Australian Financial Review*, the CEO of Australia's Sustainable Energy Industry Association contends that curbing GHGs "will not hurt most Australian business". He asserts that "The industries predicted by economic modellers to suffer under a greenhouse response scenario are already converting threat into opportunity". He says improved technology in the Australian aluminium and cement industries has boosted productivity while cutting emissions.

Workability of the regulatory approach. Arguably the case for painless emission reductions implies mandatory solutions are unnecessary. However, those backing the regulatory approach tend to believe that companies cannot be counted upon to implement meaningful changes without government prodding. For example, during an *Atlantic Monthly* on-line roundtable devoted to environmental issues (www.theatlantic.com/unbound/roundtable/environment/) Eileen Claussen of the Pew Center on Global Climate Change said "Committed industry leaders are helping us gain a perspective on what needs to happen – and how our objectives can be achieved. But, in order to succeed, we need a governmental framework, nationally and internationally".

Efforts to fashion a national and international governmental framework have been evolving for 40 years. Recent and projected events are highlighted in Exhibit 24.

EXHIBIT 24. MAJOR GOVERNMENT POLICY ACTIONS RELATING TO GLOBAL WARMING



European countries, particularly Sweden, Austria, Finland, and Germany, have supported government action on climate change for years. The RIIA analysts note in *The Kyoto Protocol* that, "by 1990, many European countries had adopted indicative targets for limiting CO₂ emissions, and pressed for such responses across the industrialised world".

Over the past decade a set of international policies has come into focus. In 1992 most of the world's governments signed the United Nations Framework Convention on Climate Change (UNFCCC), which expresses the "aim" that the major industrialised countries listed in an Annex I should reduce their GHG emissions to 1990 levels by 2000.

After the IPCC in its 1995 report stated that reductions in GHG emissions are economically feasible, negotiations began to agree tougher requirements, and in late 1997 the parties to the UNFCCC

met in Kyoto, Japan, and hammered out the Kyoto Protocol to the UNFCCC. The core of the treaty is a set of binding GHG emission reductions that are to be taken by developed nations, some of which are shown in Exhibit 25. These are to be achieved by 2008-2012 and are calculated to produce global GHG emissions that are at least 5% below those of 1990. "Demonstrable progress" is to be shown by 2005. The treaty makes reference to a second commitment period after 2008-2012, and says negotiations on the corresponding emissions levels are to start no later than 2005.

As Exhibit 25 shows, some countries have obligations that entail no change from the 1990 emission levels, or that permit increases. However, in many cases GHG emissions have increased since 1990 and thus even those allowed positive variances may need to cut back to comply. The 2010 projections are from government reports and in some cases are more optimistic than other estimates.

EXHIBIT 25. CHANGES FROM 1990 GHG EMISSIONS UNDER THE KYOTO PROTOCOL, COMPARED TO PROJECTED EMISSIONS

COUNTRY	% CHANGE FROM 1990 LEVEL THE PROTOCOL REQUIRES BY 2008-2012	PROJECTED NET % CHANGE FROM 1990 LEVEL BY 2010, ALL GHGs	PROJECTED % CHANGE FROM 1990 LEVEL BY 2010, CO ₂ ONLY
Australia	+8	+28	+40
Belgium	-8	+12 (2005)	+15 (2005)
Canada	-6	NA	+19
France	-8	-6	+8
Germany	-8	NA	-16
Ireland	-8	+10	+33
Italy	-8	-7	-4
Japan	-6	+24	+20
Netherlands	-8	+5	+9
New Zealand	0	+12	+43
Norway	+1	+8	+33
Portugal	-8	NA	+68
Russian Federation	0	-11	-3
Spain	-8	NA	+25
United Kingdom	-8	-7	+3
United States	-7	+26	+23

SOURCE: THE KYOTO PROTOCOL, ROYAL INSTITUTE OF INTERNATIONAL AFFAIRS

Countries obliged to show emission reductions do not necessarily have to meet their obligations entirely by actually cutting GHG emissions within their borders. Provisions in the treaty create "flexibility mechanisms" that include trading emission allowances (within and among countries), sponsoring emission-reduction projects in developing countries not subject to reductions, and planting trees that will absorb CO₂.

However, there is opposition to making use of these provisions – as abundantly illustrated in The Hague, EU governments and many non-governmental organisations (NGOs) think the Kyoto emission-reduction goals are if anything too modest, and/or harbour suspicions about the efficacy of the flexibility mechanisms.

Greenpeace International advocate much more aggressive GHG curtailments linked to their own set of climate targets. These are far beyond what would be accomplished if the Kyoto commitments were met. Greenpeace make no apologies – in fact, they say "these targets might well have to be strengthened in the future as a result of future scientific developments". The book *Fossil Fuels in a Changing Climate*⁴⁹, published by the Oxford Institute for Energy Studies, says compliance with the Kyoto Protocol would not have a significant effect on GHG emissions and suggests a broader approach.

Greenpeace also fault the flexibility mechanisms. In their *Guide to the Kyoto Protocol* (available at www.greenpeace.org), Greenpeace insist that the flexibility mechanisms "have the potential to undermine and even overwhelm the Protocol's global reduction target". A particular focus is the possibility that actual GHG emission reductions will be minimal because countries will buy emission allowances from Russia and other countries of the former Soviet Union. Emissions there have dropped by around 30% since 1990 in the tumultuous aftermath of the Soviet Union's collapse, and these countries' baseline emission levels reflect substantial amounts of energy-intensive economic activity that vanished after 1990. If industrial nations avoid lowering emissions by buying surplus Russian allowances, then no GHG reductions occur. This is different from trading conducted between countries where emission

abatement is expensive or otherwise difficult and countries where it is cheaper and easier – in the latter case abatement happens in one country rather than another, but it happens.

Greenpeace is hardly alone in wishing for tougher rules. The Climate Network Europe group in Brussels term the inclusion of the emissions trading option in the Kyoto Protocol "significant cause for concern" and considers the idea of promoting the use of forests as CO₂ sinks "worrying". Among the Green Party's international policy stands is a requirement that developed nations meet 75% of their required GHG reductions inside their borders.

For some regulatory approach supporters, the flexibility mechanisms are evidence of bad faith on the part of polluting corporations and politicians beholden to them. Just before the Conference of Parties in The Hague, the *Frankfurter Rundschau* carried a commentary lamenting that industrial nations' governments approved the Kyoto Protocol only because "they had succeeded in building a whole series of loopholes into the treaty. And since then they have enlarged them so much through hard work and destructive energy that the climate protection protocol is hardly worthy of its name any more".

Yet to be determined is whether the Kyoto Protocol will come into force. At least 55 Annex I countries must ratify, and over 20 have done so. However, the largest countries must ratify in order for the treaty to take effect – the parties ratifying must account for at least 55% of the total CO₂ emissions for 1990. In practice this means ratification is required by two out of the three major carbon emitters – the EU, Russia, and the US. The US Senate (which approves international treaties) has voted 95-0 to reject the Protocol, and if the Senate were to remain opposed this would hamper ratification elsewhere.

Ratification of the Kyoto Protocol is clearly a difficult challenge but is not necessarily impossible. Eileen Claussen of the Pew Center said during the *Atlantic Monthly* on-line roundtable that the treaty is "still very much alive". She claimed that several European countries are apt to ratify if negotiations on flexibility mechanisms are concluded to their liking. Some observers maintain the failure of the 2000 Conference of Parties does not doom the treaty – they argue its viability is confirmed by the fact that the participants came so close to agreement before the meeting was suspended (not adjourned).

The EC claims Europe is on track to satisfy the Kyoto goals even though the treaty has not been ratified. In September 2000 an EC staff official told reporters: "Our calculations show that if we do what we promise to do in the fields of renewables, taxation, et cetera, in the member states and at Community level we are quite confident we will reach those levels". If Europe's performance fulfils this expectation, it could help the ratification campaign by providing evidence that the Kyoto plan is indeed workable.

Gregg Easterbrook thinks Dr. James Hansen's new thesis that GHGs other than CO₂ should receive more near-term attention might make ratification easier. During the *Atlantic Monthly* on-line roundtable he asked, "So what will happen to the Kyoto treaty if the focus is shifted from restricting use of fossil fuels – a bruising prospect at best – to restricting such things as methane leaks, which nobody favors anyway?" His answer: "What will happen is, wham bang, suddenly the treaty will look attractive".

Some Kyoto Protocol backers hope to see an announcement that it has entered into force at the 2002 UN Environmental Summit – perhaps back in Japan where it was negotiated.

Failure to ratify the Kyoto Protocol would not necessarily be fatal to the regulatory approach, though. Some countries might adhere to the Kyoto plan or something similar even if it were never formally approved. The president of an environmental consultancy is quoted by *The Economist* as saying some form of domestic or pan-regional emissions restrictions are inevitable in Europe over the next five years. Some are already appearing – France has unveiled a tax on energy-consuming industries as part of a 10-year plan to curb emissions. In April 2001 a Climate Change Levy goes into effect on UK commercial use of electricity, gas, coal, and liquefied petroleum gas. According to a December 2000 report in the *Kyodo News*, Japan's Central Environment Council will advise the government to adopt a CO₂ tax. In the US, scientists at five government-supported research centres have recommended a tax on industries and electric utilities equal to \$50 for each ton of CO₂ discharged into the atmosphere. There could even be state-level abatement programmes in the US regardless of whether the Senate ratifies the treaty – support for that possibility can be found in the April 2000 adoption by the State of New Jersey of a plan for reducing GHG emissions within its borders 3.5% by 2005.

The RIIA analysts believe the Kyoto Protocol will inevitably win support as the only real hope for taking action:

Governments have already made major political investments to establish this nascent regime. It offers a solid basis, and there are no credible alternatives to offer. The world has started down an ambitious and efficient road to tackle its most daunting environmental problem, and there is no turning back.

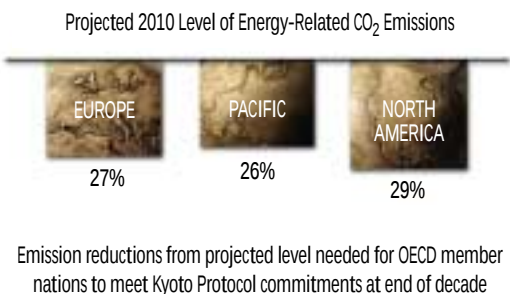
SECOND POSSIBILITY: VOLUNTARY ACTION WILL SUFFICE

Those placing more faith in voluntary, market-based solutions generally doubt government-driven efforts would be cost-effective in reducing GHG emissions and fear they would misdirect both public and private expenditures. And many believe support for their view will be strong enough between now and 2010 to defeat attempts to approve or execute compulsory restrictions.

Perspective on economic impact. Whilst many official projections of the economic impacts of GHG restrictions depict them as manageable if not positive, sceptics challenge such projections. They are dismayed by the prospect of fees and fiats being imposed on GHG-emitting businesses, believing these will throw sand in the gears of economies everywhere. Some studies of the economic implications of GHG cutbacks are said to substantiate their concerns.

For example, Exhibit 26 is based on figures from the 1998 edition of the IEA's World Energy Outlook. It shows an IEA estimate that, as of 2010, OECD member countries' CO₂ emissions from all sources could have to be cut by more than 25% to meet Kyoto commitments if flexibility mechanisms are not used. The projections assume some increase in the proportion of natural gas use by electricity generators, some new nuclear plants, an increase in utilities' use of renewables, and a rise in energy use below that of economic activity.

EXHIBIT 26. ESTIMATE OF ENERGY-RELATED CARBON EMISSION REDUCTIONS REQUIRED IN 2010



SOURCE: IEA

To provide a frame of reference for assessing what might be required to close the gap, IEA note that if the job of erasing the 3.8 billion tonnes of excess CO₂ emissions in 2010 were allocated equally between energy end use and power generation, this would mean reducing by 1.9 billion tonnes the estimated 5.3 billion tonnes of CO₂ emissions from power generation that year. Coal would be a natural focus when seeking CO₂ reductions, since it is the fuel that produces the most emissions. However, the IEA projections assume that most new generating plants added by 2010 will be gas-fired and therefore the only way to reduce coal use in power generation would be to curtail output from existing coal-fired plants. In summary, the IEA scenario illustrates that power generation in general and coal-fired generation in particular could be hard-hit by GHG restrictions if emissions trading and other flexibility mechanisms are limited. Even spread out over prior years, reductions in the utility sector would be significant.

The comparatively low GHG emissions from natural gas mean it would be less affected by controls, but by some accounts it, too, would suffer. WEC Secretary General Gerald Doucet points out that including carbon costs would add 3-4% to the full cost of natural gas, even assuming a low carbon value of \$9 per tonne of carbon.

At the country level, a GCC summary of four studies on how the Kyoto Protocol GHG limits could affect the US economy shows that "in the most likely scenarios, lost GDP in 2010 alone could range from \$225 billion to about \$440 billion". An EIA analysis of potential impacts by 2010 based on pessimistic assumptions shows petrol prices soaring an additional 66 cents a gallon, electricity rates rising 20% to 86%, natural gas prices rising by 147%, and GDP dropping by as much as 4%. The EIA calculated GDP declines of \$77 billion to \$338 billion annually. The EIA assumed no trading of emissions allowances and a delayed start in cutting CO₂ use, conditions stipulated by the Republican committee chairman who ordered the study.

In the US controversy has flickered around the issue of the impact of carbon controls on minorities. A report issued in mid-2000 concluded that implementing the Kyoto Protocol would

diminish the earnings of 25 million black and Hispanic workers in the United States by 10% and throw 864,000 blacks and 511,000 Hispanics out of work. The report was commissioned by six African-American and Latino groups and was paid for by the Center for Energy and Economic Development, which is backed by the coal industry.

The president of the US labour union representing coal miners whose jobs could be threatened by implementation of the Kyoto agreement told Congress in 1998 that "we believe that the Kyoto Protocol will have serious negative effects on U.S. jobs, economic growth, family incomes, and trade, but have almost no positive effects on carbon concentrations". He warned that "over a million jobs could be lost, and the losses will occur in every region of the country".

The Allen Consulting Group looked at the potential impact on Australia. It reported that if Australia did not use international trading to reduce its GHG emission reduction quotas, and if the burden of achieving its mandated reduction were placed solely on the energy-generation sector, Australia's real GDP would decline by 2.4% and employment would fall by 3.6%. The Australian Aluminium Council fears that implementing the Kyoto Protocol "could expose Australia and its major trading partner Japan to high cost compliance measures which would undermine competitiveness in key trading industries".

A particular concern is the impact on companies in countries, or parts of countries, that will be experiencing rapid economic growth just as GHG restrictions might be applied – those affected argue they will be put at an unfair disadvantage compared to areas whose steepest growth is behind them and/or that are not subject to constraints. The state of Western Australia has protested that its economic aspirations are jeopardised because it is experiencing industrial growth at the point when GHG restrictions are apt to be invoked, citing projections it could lose to countries without GHG restrictions investments involving \$10.2 billion Australian and up to 16,700 jobs.

Many energy end-users in developed countries are uncomfortable with their lot under the Kyoto Protocol. They object to the compulsory, time-limited aspects of the plan, and fear the competitive implications of being subject to constraints which rivals in other countries are not.

The Geneva-based International Federation of Industrial Energy Consumers say:

The climate change issue and the direction of the Kyoto Protocol has potentially serious negative implications for the competitiveness of industrial energy consumers. Industrial energy consumers can do their part through voluntary energy efficiency agreements. The only real solution for significant consumer emission reductions by this sector is the development and use of new technology which requires a much longer time frame than that accorded under the Kyoto Protocol.

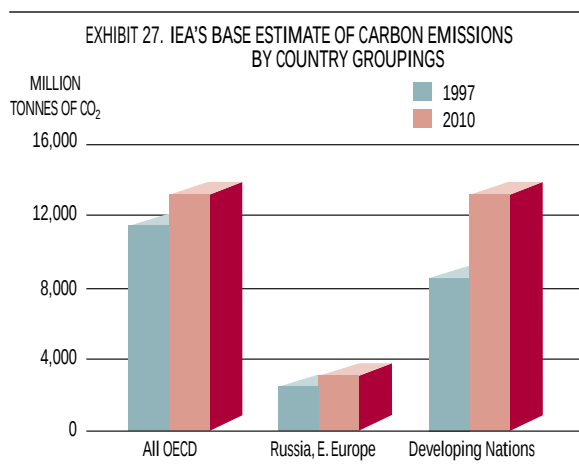
Among those who believe government solutions could be much less benign than Kyoto Protocol defenders and others envision is Peter Huber, Washington-based lawyer, Forbes columnist, and Manhattan Institute fellow. In his book *Hard Green*²⁰ he questions the accuracy of the calculations behind arguments that remedial actions such as those the Kyoto Protocol prescribes will produce benefits that outweigh the costs. "Central planners never get the time value of money right, he charges. "They never get the value of anything right. Only free people and free markets come anywhere close".

Some activists reinforce the impression that achieving major GHG reductions would require huge social and economic adjustments. For example, during the *Atlantic Monthly* on-line roundtable, environmentalist Bill McKibben said global warming probably cannot be solved without changes in the way of life typical

in industrialised countries that are so fundamental "very few of the world's political leaders are willing to even raise them as possibilities (except, increasingly, in some parts of Europe)".

Workability of the voluntary approach. Proponents of voluntary action rest much of their case on what they see as flaws in the regulatory approach. They contend the Kyoto Protocol is an example of government-driven solutions that are ineffective while creating undesirable side effects, and insist the contentious politics surrounding the treaty hamper its functioning. Their suspicions of a "big government" agenda were aroused when French President Jacques Chirac told the Hague conference that the Kyoto Protocol is "the first component of an authentic global governance." They laud market-based responses because they see them as more efficient and more proportional to the problems they address.

For example, in Congressional testimony the GCC testified that the treaty is "badly flawed" and "unworkable", and contains "unrealistic targets and timetables". Organisations such as the GCC claim the fact that the treaty subjects industrialised countries to burdensome emission restrictions while exempting major developing nations not only makes net GHG reductions unlikely but also represents a glaring inequity. The lack of constraints on developing nations has been a prime issue blocking ratification in the US Senate. Exhibit 27 shows the CO₂ emission projections under the IEA's reference scenario, indicating that developing nations not bound by the Kyoto Protocol could be responsible for releasing essentially the same amount of carbon into the atmosphere by 2010 as the OECD nations.



SOURCE: IEA

Free-market proponents believe flaws in the Kyoto Protocol will become increasingly apparent. For example, the GCC say prospects for US ratification look "increasingly bleak". A panel at a late-1999 conference of the Energy Council of Canada agreed that, although a hydrogen-based energy system will be developing there by 2050, this will occur "in the absence of a global commitment to take the actions necessary to curb carbon dioxide emissions". In 2000 the Canadian environmental minister declared a proposed carbon tax politically unwinnable, and a meeting of federal and provincial governments broke up without settling GHG restrictions when Quebec walked out. The RIIA *Kyoto Protocol* authors acknowledge that even in Europe there is resistance to restrictions among poorer, developing countries that do not wish to be bound by controls stemming from richer countries' emissions.

As the RIIA analysts observe, the longer ratification is delayed, the more arduous is the task of complying, and the more difficult it becomes to win political approval:

If significant action were deferred beyond about 2004, the adjustment required would start to pose an insurmountable obstacle. US opponents of ratification do not need to win the argument; they simply need to delay losing it long enough to make the task of implementation too daunting.

Environmentalists arguably could hurt the treaty's cause rather than help it. In the *Atlantic Monthly* on-line roundtable Gregg Easterbrook argued that environmental activists are unintentionally bolstering the impression government controls are ineffective by refusing to admit years of pollution programmes in the US and Europe have made things better. He advocated "admitting that doomsday thinking no longer applies to the Western environment" but said "I don't see any sign that the enviros are politically ready to do that".

Peter Huber contends government mandates are not needed to induce private companies to be environmentally responsible. In *Hard Green* he says, "The rich capitalist microscopically tunes and adjusts the fuel-air mixture in his giant power plant because each tiny uptick in efficiency saves him millions". Leaving private enterprise alone results in technological advances and the accumulation of wealth, which Huber sees as the key drivers of

environmental protection because poor people lack the means and motivation to conserve. "The rich, not the poor, are the ones actively committed to conserving wildlife, forest, seashore, and ocean".

Why trust the market system to know what steps are appropriate for ameliorating global warming? Huber's answer is that:

In a free market, every individual chooses continually between consumption and saving, between bird in hand and bird in the bush, between what we know how to do today and what we can reasonably expect to be able to do tomorrow. In the aggregate, individuals make far better choices from the bottom up than the wisest planners can impose from the top down.

Like many free-market advocates, Huber thinks a commerce in the right to pollute offers a sure means of controlling GHG emissions and other pollutants. Accordingly he advocates "privatising pollution". He favours issuing pollution permits in quantities that mirror established patterns of activity and then watching as pollution abatement technologies emerge that allow companies to cease polluting and sell their rights. "The more freely people can buy, sell, and trade pollution and permits," Huber claims, "the more pollution we will abate".

A paper prepared by Battelle for the Pew Center on Climate Change concludes that the "costs of controlling carbon emissions would be significantly lower if trade in carbon emissions were permitted". It links this to the fundamental precept that "where relative costs of performing an activity differ among individuals, business firms, or regions, there are almost always potential gains from trade". An article in the *Harvard Business Review* reflects the same point of view: "A global trading system for carbon dioxide would... enable the global community to reduce emissions where it can do so most cheaply – just as free markets concentrate production of wheat, oil, semiconductors, and software in places

where those goods can be made at the lowest cost". And the White House Council of Economic Advisors says in its 2000 report that tradable permit systems are better than traditional regulatory approaches "because they promote the cost-effective attainment of emissions reductions".

As noted previously, implementation of the Kyoto Protocol is not necessarily incompatible with extensive reliance upon emissions trading. The flexibility mechanisms provide for trading, and a lively market in emissions allowances could function within the treaty framework if the parties let it happen.

Exhibit 28 shows a rough calculation by the IEA of the cost of meeting Kyoto Protocol targets if trading is employed. In their *World Energy Outlook 2000*, the IEA assume as they did in their 1998 report that OECD countries will fail to reach their targets by the end of the decade. After citing the expense of suppressing emissions within OECD countries by focusing on domestic sources, the IEA argue that "Emission trading thus becomes critical to achieve the emission objectives of the Kyoto Protocol at politically acceptable economic cost". The IEA do not see a problem if OECD countries buy unused emission allowances from Russia and East Europe: "So long as the agreed-upon environmental goal is met, there is no reason not to meet it at the least possible cost, even including 'hot air'".

EXHIBIT 28. IEA'S CALCULATION OF THE COST OF USING PERMIT TRADING TO COMPLY WITH KYOTO TARGETS IN OECD COUNTRIES

Assumes that countries gradually augment emission-reduction policies between 2001 and 2008. Price of permit to emit one tonne of carbon assumed to be \$26.

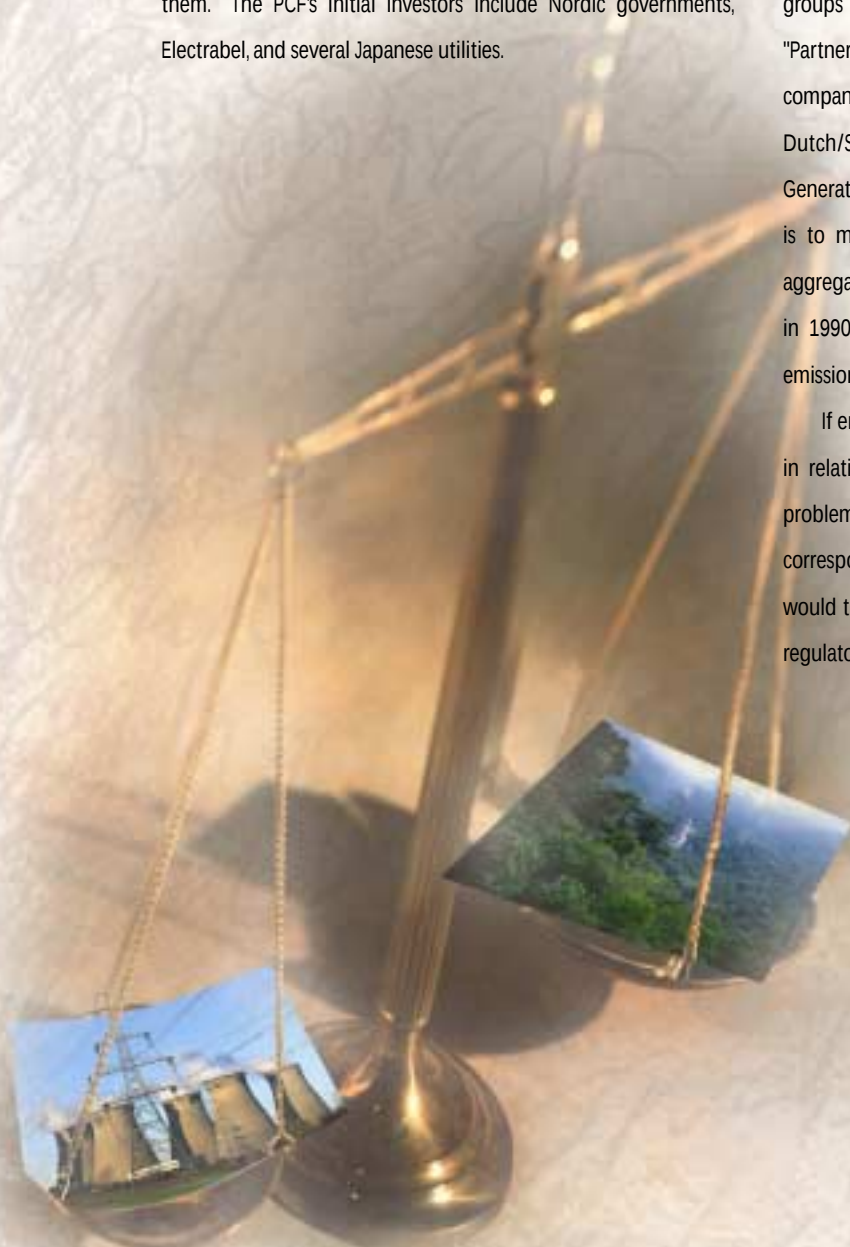
ANNUAL COSTS 2010		CUMMULATIVE COSTS 2001-2012 DISCOUNTED AT 3% PER ANNUM		
MILLION US \$	% OF 2010 GDP	MILLION US \$	% OF 2000 GDP	
			CO ₂ ONLY	ALL GHGs
56,266	22	219,794	1.07	1.33

SOURCE: IEA

Some foresee an explosion of trading in emissions as the decade proceeds. Early efforts in that direction are already underway. An International Emissions Trading Association has been formed with participation by entities such as the Australian Stock Exchange, BP, the International Petroleum Exchange, Lloyd's Register, Shell, Statoil, and Tokyo Electric Power. BP has launched an internal CO₂ trading scheme among its divisions. UNIPED and the IEA have conducted a simulation of electricity and CO₂ trading. Denmark's electric utilities are to begin trading GHG permits in 2001. Meanwhile, the World Bank has created a Prototype Carbon Fund (PCF) to help determine the appropriate price of carbon emissions, with the objective of encouraging companies to invest in cutting them. The PCF's initial investors include Nordic governments, Electrabel, and several Japanese utilities.

Private sector initiatives are growing. The GCC has documented more than 1,500 voluntary projects by US companies in 1998, a three-fold increase in just four years. A number of companies are already trying bilateral arrangements. American Electric Power is spending \$5.5 million on protecting rainforests in Bolivia to offset emissions from its coal-fired generating plants. Ontario Power Generation is offsetting 2.5 million tonnes of CO₂ emissions by buying credits from a small US firm that captures methane from landfills for use in power generation. In Japan 42 industries including utilities have set voluntary emission reduction targets in accordance with the "Keidanren Voluntary Action Plan on the Environment". Reviewers from universities and environmental groups check reported progress annually. Similar in concept, a "Partnership for Climate Action" has been formed by seven Western companies and an environmental group. The members are BP, Royal Dutch/Shell Group, DuPont, Suncor Energy, Ontario Power Generation, Alcan Aluminum, and Pechiney. Environmental Defense is to monitor results. The objective is to reduce the group's aggregate CO₂ emissions from 360 million tonnes of GHG emissions in 1990 to 280 million in 2010. The companies plan to trade emission allowances among themselves.

If emissions trading and voluntary efforts are seen as sufficient in relation to the perceived seriousness of the global warming problem, recourse to command-and-control solutions would be correspondingly reduced. Activity pertaining to GHG emissions would then be prominent but would occur on a basis different to regulatory scenario.



Summary of Differing Assumptions About Climate and Fossil Fuels

We have divided our examination of how climate change issues might affect the energy business during the 2000-2010 period into two parts: (1) the question of whether GHGs will be seen as promoting dangerous global warming, and (2) if so, whether the world will decide the best solution is compulsory, government-led solutions or voluntary, market-based approaches. The current struggle for the ear of policymakers and public opinion offers glimpses of the divergent paths the world could follow during the new decade. Exhibit 29 summarises contrasting opinions and predictions bearing upon the outcome.

EXHIBIT 29. CONFLICTING VIEWS ON GLOBAL WARMING AND GOVERNMENT-DRIVEN SOLUTIONS

	ISSUE	PESSIMISTS/CONTROL ADVOCATES	OPTIMISTS/FREE-MARKET ADVOCATES
	Reliability of measurements and computer models used to analyse and project warming trends	Reliable, or at a minimum reliable enough to justify concern and remedial action	Numerous weaknesses and anomalies in measurements make many readings suspect. As for models, they don't do a good job of replicating today's climate, and their projections of future warming have been adjusted downward, so beware using their data as basis for action.
	Rise in mean surface air temperatures over past century?	Increase of 0.6°C (1°F), with a sharp rise in recent decades.	Agree, but factors such as El Niño have played a role.
	Rise in mean surface air temperatures over next century?	Will be substantial, on the order of 1.5 - 6.1°C (2.7 - 11°F).	Warming predictions are based on incomplete knowledge, worst-case scenarios. For example, CO ₂ build-up could trigger natural reactions that would negate warming effect. At most the increase might get near the low-end estimate, but there is also the possibility coming decades will bring a cooling trend.
	Cause of past and future increases?	Whilst proof is not conclusive, there are strong reasons to believe GHGs are a significant factor.	At most, GHGs appear to be a minor factor – much more likely that warming is due to natural cycles.
	How much are GHGs likely to increase?	Economic and population growth mean major increases, on the order of 30% between 1997 and 2010.	Increasing energy efficiency will limit CO ₂ emissions and minimize any adverse climate effects.
	How sensitive is the atmosphere to GHG increases?	A doubling of GHG concentrations would cause significant warming, on the order of 1.7 - 4.4°C (3 - 8°F).	A doubling of GHG concentrations would cause limited warming, on the order of 0.2 - 1.1°C (0.5 - 2°F).
	Seriousness of warming effects?	Serious risk to property, crops, human life and health from severe weather, rising ocean levels.	Effects could be negligible or even positive, e.g., warmer weather boosts crop yields. Any adverse effects would develop so slowly there would be ample time to avoid problems or adjust.
	Relationship between warming and bad weather	Global warming is causing more and worse storms.	Some data show no increase in bad weather. Other data show bad weather is increasing, but due to natural causes. Some data show warming will temper storms. Even worse weather might not be abnormal by historical standards.
	Appropriate policy approach	Continue efforts to refine knowledge, but meanwhile push ahead on the assumption remedial action is required.	Remedial action is a bad idea in the absence of clear evidence there is a problem and GHGs are a factor. Ill-advised actions could do more harm than good.
	Efficacy of Kyoto Protocol prescriptions	Prescribed reductions are minimal compared to need, and many provisions are too lax.	Prescribed reductions are draconian and more discretion should be left to private sector and market forces.

CONCLUSION

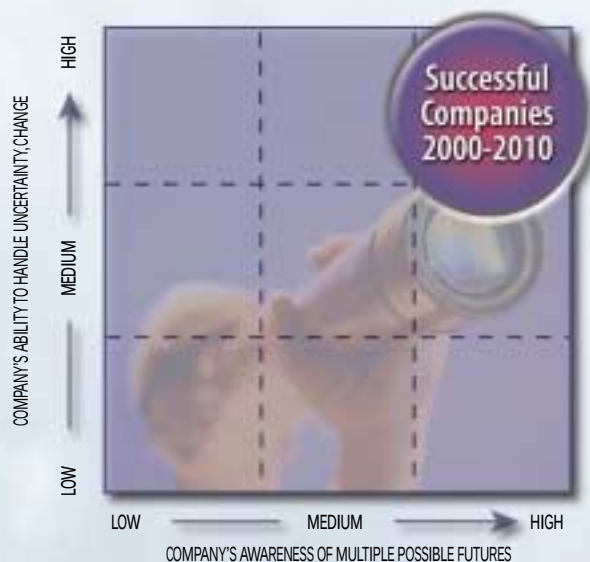
As this portion of *The Utility Executive's Field Guide to the Future* has shown, the prospects for fossil fuels are uncertain. Will cheap oil and gas reserves dwindle or expand? Will energy flow unimpeded, or will politics and other factors interfere? Will climate concerns intensify or wane? It is simply hard to say. There are many plausible pathways to the future, and reputable sources differ widely on the question of how fossil fuels will fare in tomorrow's marketplace.

With conditions this unsettled, companies are vulnerable to becoming too locked into one set of assumptions as to how things will turn out. Almost any forecast or hypothesis will be off to some degree, and the odds of being spectacularly wrong are far higher than before.

What can utilities do to minimize the risk of being wrong without becoming paralysed by indecision? For this kind of business environment, Deloitte Research believe successful companies will exhibit two kinds of capabilities. First, prior to defining their strategies they will identify and assess the full range of possible futures. Second, whenever things do not fall into place as expected, they will move rapidly to meet the new challenges and opportunities. Achieving the latter will be easier for successful companies because they will recognise at least some aspects of the new circumstances from their previous investigation into possible market conditions, and they will have the organisational traits needed for fast adaptation. In the conceptual framework depicted in Exhibit 30, successful companies will be in the upper right corner.

More specifically, defining winning strategies will entail the use of tools designed for planning in a complex and volatile world, such as scenario-building, real options valuation, and computer modelling (the x axis in the chart). These approaches provide the means for understanding the array of strategic choices available and for defining the significance of selecting or not selecting particular

EXHIBIT 30. CORPORATE CAPABILITIES PROMOTING SUCCESS DESPITE UNCERTAINTY



SOURCE: DELOITTE RESEARCH

courses. Coping with the inevitable surprises once a direction is chosen will involve reliance upon systems, processes, and a culture that make a company versatile – that permit it to nurture "just-in-case" technologies, products, and businesses, spot leading indicators of change, and switch strategies without confusion and delay (the y axis in the chart).

By illuminating the many incompatible perspectives on what lies ahead, this and the other parts of the *Field Guide* demonstrate why it is so inadvisable to rely on one theory of what conditions will prevail over the next few years – especially if the assumptions have not been well articulated and carefully examined. The new decade will demand methods of making decisions and managing organisations that allow executives to work with change rather than denying or ignoring all the uncertainty. This is a time of complex possibilities, and the best approach is to address that reality.

End Notes

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